5/11/84

OPERATING AND SERVICE MANUAL

438A
POWER METER

PRELIMINARY MANUAL
SEE INSIDE COVER FOR MAILER

HEWLETT PACKARD

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Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

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IMPORTANT

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438A

POWER METER

This Preliminary Manual is supplied to permit earliest possible delivery of your instrument. The information is as complete as possible at this time.

This request card entitles you to one copy of the final Operating and Service Manual for this instrument. To receive your copy of the final manual when it is available, fill out, detach and return the card (no postage necessary when mailed in the United States).

Type or print your full name and address in the spaces provided. Be sure to enter the full serial number of the instrument, and mail this card within six months of the date you received your instrument.

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OPERATING AND SERVICE MANUAL

438A
POWER METER
(Including Option 002)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2333A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY THIS MANUAL in Section I.

HEWLETT PACKARD

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SAFETY CONSIDERATIONS

GENERAL

This product and related documentation must be reviewed for familiarization with safety markings and instructions before operation.

This product is a Safety Class I instrument (provided with a protective earth terminal).

BEFORE APPLYING POWER

Verify that the product is set to match the available line voltage and the correct fuse is installed.

SAFETY EARTH GROUND

An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set.

WARNINGS

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury. (Grounding one conductor of a two conductor outlet is not sufficient protection.) In addition, verify that a common ground exists between the unit under test and this instrument prior to energizing either unit.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

If this instrument is to be energized via an autotransformer (for voltage reduction) make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

Servicing instructions are for use by service-trained personnel only. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

For continued protection against fire hazard, replace the line fuse(s) only with 250V fuse(s) of the same current rating and type (for example, normal blow, time delay, etc.). Do not use repaired fuses or short circuited fuseholders.

SAFETY SYMBOLS

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual (see Table of Contents for page references).

Indicates hazardous voltages.

Indicates earth (ground) terminal.

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

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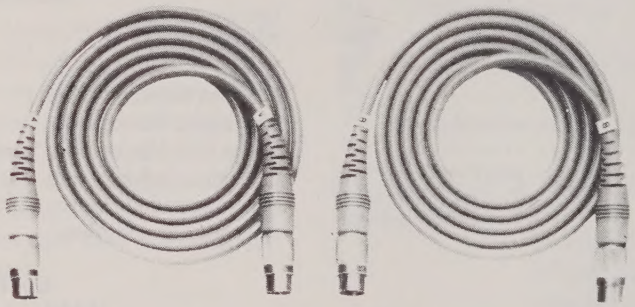
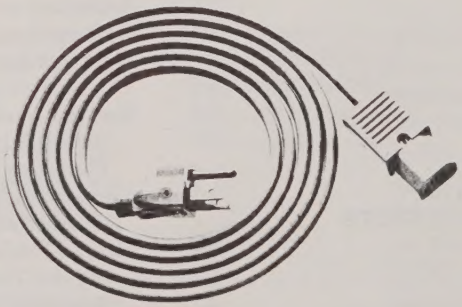
MODEL 438A



POWER SENSOR CABLES



LINE POWER CABLE

Figure 1-1. HP Model 438A Power Meter with Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This manual contains information required to install, operate, test, and service the Hewlett-Packard Model 438A Power Meter. The Power Meter is shown in Figure 1-1 with all of its externally supplied accessories. This manual also documents Option 002 which adds the capability of rear panel sensor inputs and a second reference oscillator output.

This section of the manual covers the instrument description, options, accessories, specifications, and other basic information. The remaining sections cover the following information.

Section II Installation

Section III Operation

Section IV Performance Tests

Section V Adjustments

Section VI Replaceable Parts

Section VII Manual Changes

Section VIII Service

Two copies of the operating information are supplied with the Power Meter. One copy is in the form of an Operating Manual and is simply a copy of the first three sections of the Operating and Service Manual. It should remain with the instrument for use by the operator. The other copy provided is the Operating and Service Manual which should be retained by the technicians responsible for the periodic servicing of the instrument. Additional copies of either manual may be ordered through your nearest Hewlett-Packard sales office. The part numbers are listed on the title page of this manual.

The Operating and Service Manual is also available in microfiche form, and the microfiche part number is listed on the title page. This number may be used to order the 100 X 150 mm (4 by 6 inch) microfilm transparencies. Each transparency contains up to 98 photo-duplicates of the manual pages and the package includes the latest manual change supplements.

1-2. SPECIFICATIONS

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested. Supplemental characteristics are listed in Table 1-2. Supplemental characteristics are not warranted specifications, but are typical characteristics included as additional information for the user.

1-3. SAFETY CONSIDERATIONS

This product is a Safety Class I instrument (i.e., provided with a protective earth terminal). The Power Meter and all related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of the safety information. Safety information pertinent to the task at hand (installation, performance testing, adjustment, or service) will be found throughout the manual.

1-4. INSTRUMENTS COVERED BY THIS MANUAL

This instrument has a two-part serial number in the form of 0000A00000. The number is stamped on the serial number plate attached to the rear panel of the instrument. The first four digits and the letter constitute the serial number prefix, and the last five digits form the suffix. The prefix is the same for all identical instruments, and it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under Serial Numbers on the title page.

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates that the instrument is different from those documented in the manual. The manual for a newer instrument is accompanied by

INSTRUMENTS COVERED BY THIS MANUAL (cont'd)

a yellow Manual Changes supplement which contains the change information that explains how to adapt the manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. In order to keep your manual as current and accurate as possible, it is recommended that you periodically request the latest Manual Changes supplement. The supplements are identified with the manual print date and part number, both of which appear on the manual title page. Complimentary copies of the supplements are available from Hewlett-Packard.

For information concerning a serial number prefix that is not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-5. DESCRIPTION

The Hewlett-Packard Model 438A Power Meter is a microprocessor controlled dual channel (A and B multiplexed) meter. It measures power in the range of −70 to +44 dBm over the frequency range of 100 kHz to 26.5 GHz using the existing Hewlett-Packard 8480 series power sensors. A 1.00 mW 50 MHz POWER REF (reference) is available for calibrating the meter to the sensor's sensitivity.

The meter displays power in the following modes; dBm, dB Rel (relative), watts and % Rel (per cent relative). The measured ratio and difference of two inputs can be displayed. The power ratio is displayed in either dB or % while the power difference is displayed in either watts or dBm. The ratio or difference power readings of a single sensor input are displayed relative to a stored reference. Also displayed are the possible error states of the meter.

Zeroing, calibration, and offsets are capabilities of the meter that can be set either locally by the front panel keys or remotely over the Hewlett Packard Interface Bus (HP-IB). When these routines are finished the meter resumes measuring and displaying the input power.

The meter has both manual and automatic ranging. In the AUTO RANGE mode the meter automatically switches through its five ranges and in the MNL RANGE (manual range) mode one of the five ranges can be selected.

Memory capacity for saving up to 19 front panel settings is built into the meter and can be accessed by using the STORE and RECALL keys.

1-6. OPTIONS

1-7. Electrical Option

Option 002 provides the additional capability of having two power input connectors on the rear panel in parallel with the front panel inputs and a rear panel connector for an additional power reference oscillator .

Option 004 deletes the two HP 11730A sensor cables normally supplied with the power meter. Refer to cables in this section for other cables available.

1-8. Mechanical Option

A mechanical option kit is available containing hardware and installation instructions for adding handles to the meter. To obtain front handle kit Option 907 order HP part number 5061-0088.

1-9. ACCESSORIES SUPPLIED

The accessories supplied with the Power Meter are shown in Figure 1-1. The line power cable will be supplied in one of several configurations, depending upon the country of destination for the original shipment from the factory. Refer to Power Cables in Section II of this manual. Two power sensor cables, HP part number 11730A, are supplied.

1-10. ACCESSORIES AVAILABLE

1-11. Rack Mounting Kits

These kits are very useful when the Power Meter is to be rack mounted. It permits access to internal circuits and components, and access to the rear panel is possible without removing the instrument from the rack.

Rack mounting one meter. Order HP part number 5061-0072 which includes one rack flange and one extension adapter.

Rack mounting two meters. Order the following: HP part number 5061-0074 two rack flanges, and HP part number 5061-0094 cabinet locking hardware.

Rack mounting one meter with slides. Order the following: HP part number 5061-0096 support shelf, HP part number 1494-0041 two slides, and HP part number 5061-2022 filler panel.

ACCESSORIES AVAILABLE (cont'd)

Rack mounting two meters with slides. Order the following: HP part number 5061-0096 support shelf, and HP part number 1494-0041 two slides.

1-12. Cables

Power Sensor cables with various lengths are available. The model numbers and lengths are listed below.

HP 11730A	1.5m (5 ft)
HP 11730B	3.0m (10 ft)
HP 11730C	6.1m (20 ft)
HP 11730D	15.2m (50 ft)
HP 11730E	30.5m (100 ft)
HP 11730F	61.0m (200 ft)

1-13. RECOMMENDED TEST EQUIPMENT

Table 1-3 lists the test equipment recommended for use in testing, adjusting, and servicing the Power Meter. If any of the recommended equipment is not available, instruments with equivalent critical specifications may be substituted.

Table 1-1. Specifications (1 of 2)

Electrical Characteristics	Performance Limits	Conditions
METER		
Frequency range	100 kHz to 26.5 GHz	Sensor dependent
Power range	−70 dBm to +44 dBm (100 pW to 25W)	Sensor dependent
Dynamic range	50 dB total range	40 dB full scale in 10 dB steps
Inputs	Channel A and B	Multiplexed dual sensors
Rear panel output	0—1 volt analog	Without digital filtering 1kΩ output impedance BNC connector
Measurement modes	A, B, A-B, B-A, A/B, B/A	Normal or relative all modes
Display units	Watts or dBm Percent or dB Percent or dB	Absolute A, B, A-B, B-A Ratio A/B, B/A Relative
Resolution		
Normal	0.1% full scale 0.01 dB	Auto filter watts or percent dBm or dB
High	0.01% full scale 0.001 dB	Manual filter watts or percent dBm or dB

		9	8	7	6	5	4	3	2	1	0
Highest Power	5	*	*	*	*	*	*	*	0	0	X
RANGE	4	*	*	*	*	*	*	0	0	0	X
	3	*	*	*	*	*	0	0	0	X	0
	2	*	*	0	0	0	0	X	0	0	0
Lowest Power	1	0	0	X	0	0	0	0	0	0	0

FILTER NUMBER

* High resolution
0 Normal resolution
X Auto filter

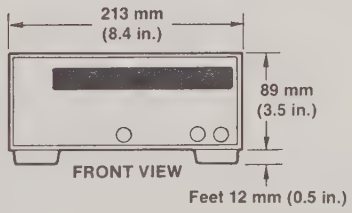
ACCURACY		
Instrumentation, includes sensor linearity[1]		
Single channel mode	±0.02 dB	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode[2] (ratio or difference)	Multiply single channel specifications by 2	

[1]When operating on the top power range add the Power Linearity percentages of the power sensor.

[2]Accuracy does not depend on the meter being in Normal or Relative mode.

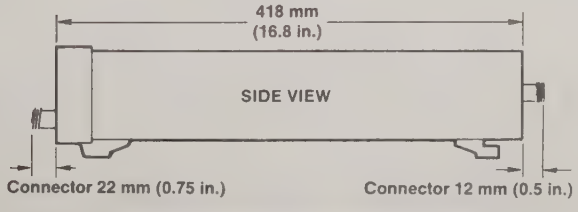
Table 1-1. Specifications (2 of 2)

Electrical Characteristics	Performance Limits	Conditions
ACCURACY (cont'd)		
Zero set (digital settability of zero)	±0.5% full scale	Most sensitive range. Decrease percentage by factor of 10 for each higher range ±1 count
Power reference	1.00 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards
Power reference accuracy	±1.2% ±0.9%	Worst case RSS for one year.
GENERAL		
Operating temperature range	0° C to 55° C	
Power requirements	65 VA, 35 watts	Maximum
Line voltage	100, 120, 220 or 240 Vac, +5%, −10%	
Line frequency	48 to 66 Hz	All specified line voltages may be used
	360 to 440 Hz	Limited to line voltages of 100 or 120 Vac
Remote operation	HP-IB	All functions except power switch, clear entry, HP-IB address
Compatibility	HP-IB interface	SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, C0
Memory	Non-volatile	Contains complete meter operating state of both channels plus contents of store/recall registers
Operating and non-operating environment	Temperature, humidity, shock, and vibration type tested to MIL-T-28800B Class V requirements.	
Safety	Meets requirements of IEC 348	
Net weight	5.9 kg (13 lb)	



Dimensions:
89 mm H x 213 mm W x 418 mm D
(3.5 x 8.4 x 16.8 inches)

NOTE: For ordering cabinet accessories, the module sizes are 3-1/2 H, 1/2 MW, and 17D.



(All dimensions in millimetres and (inches)

Table 1-2. Supplemental Characteristics

Supplemental characteristics are intended to provide information useful in applying the instrument by giving typical, but non-warranted performance parameters.

METER NOISE

As a % of full scale, with constant temperature, range 1, measured over one minute interval, and two standard deviations.

8481A, 8481B, 8481H, 8482A, 8482B, 8483A, 8485A Sensors:

Filter No.	0	1	2	3	4	5	6	7	8	9
Noise (%)	6.0	2.4	1.8	0.90	0.7	0.5	0.4	0.3	0.2	0.15

8484A Sensor: multiply noise levels by 4 for all filters. Decrease noise by a factor of 10 for each higher range for all sensors and all filters.

ZERO DRIFT OF SENSORS

As a % of full scale, 1 hour, at constant temperature after 24 hour warmup.

8481A, 8481B, 8481H, 8482A, 8482B, 8482H, 8483A, 8485A Sensors: ±0.1% of full scale on range 1.

8484A Sensor:
±2.0% of full scale on range 1.

Decrease the above by a factor of 10 for each higher range.

SETTLING TIME

0 to 99% settled readings over the bus. AUTO filter, range hold, 10 dB decreasing power step.

Single channel	<3.0 s	Range 1
	<1.0 s	2
	<150 ms	3
	<100 ms	4—5

MANUAL filter, range hold, 10 dB decreasing power step.

Single channel:

Filter No.	0	1	2	3	4	5	6	7	8	9
Response Time (s)	0.10	0.15	0.25	1.0	1.4	2.2	3.7	6.9	14.0	27.0

Dual channel (ratio or difference mode): approximately the sum of the individual response times of each channel, plus channel switching delay.

MEASUREMENT SPEED

Over HP-IB and free running trigger.
Single channel: 20 readings per second.
Dual channel: 2 readings per second.

CHANNEL SWITCHING DELAY

200 ms.

POWER REFERENCE

Frequency: 50 MHz nominal.
SWR: 1.05 maximum.
Connector: Type N female.

METER ADJUSTMENTS

Cal Factor: Key pad entry or programmable, 1—150% in 0.1% increments.

Zeroing: Front panel or programmable, zeros all 5 ranges, reference oscillator automatically switched off during zeroing.

Cal Adjust: Automatic, front panel or programmable, internal 1.00 mW reference, or external reference oscillator. Reference Cal Factor from 50.0% to 120.0%.

Channel Offset: Front panel or programmable, −99.99 to +99.99 dB in 0.01 dB increments.

Digital Filter Length: Averages power readings from 1 to 512 successive values in increments by factors of two (1, 2, 4, . . . 256, 512). Front panel or programmable.

High/Low Power Limits: Programmable only, activates Service Request and flashing front panel indicator, individual channel values from −299.999 to +299.999 dBm in 0.001 dB increments.

Store/Recall Registers: Nineteen registers to store complete operating state of meter for later recall.

Relative Mode: When activated, displays all successive measurements relative to the last value read when activated. Units are in dB or %.

Table 1-3. Recommended Test Equipment

Instrument	Critical Specifications	Recommended Model	Use[1]
Digital Voltmeter	Range: 0 to 20 Vdc Resolution: 0.01 Volt	HP 3456A	A, T
Oscilloscope	>200 MHz bandwidth	HP 1725A	T
Range Calibrator	Calibration uncertainty ±0.25%	HP 11683A	P, A, T
Signature Multimeter	Qualified Signature Analysis	HP 5005B	T
Frequency Counter	Range: 10 Hz to 50 MHz Resolution: 1 Hz	HP 5328A Option 031	P, A, T
Power Splitter	Frequency: 50 MHz Impedance: 50 Ohms Connectors: Type N	HP 11667A	P, T
Power Meter	Range: 1 mW Transfer Accuracy: 0.2% (Input to Output)	HP 432A	P, A, T
Thermistor Mount	SWR: 1.05 at 50 MHz Accuracy: ±0.5% at 50 MHz	HP 478A-H75[2] or HP 478A-H76[3]	P, A

[1]P = Performance, A = Adjustment, T = Troubleshooting.

[2]Calibrated at the National Bureau of Standards (NBS) for this accuracy.

[3]HP standards lab calibration to ±0.58% at 50 MHz (traceable to NBS).

Table 1-4. Service Accessories

Accessory*	Specification	Suggested Model
Open-End Wrench (SMC Connectors)	1/4-inch	Utica Tool Co.**, Open End Standard, Model No. OP82, 1/4-inch
Extender Board	36 contacts (2 x 18)	HP 08684-60018
Foam Pad	Conductive polyurethane foam, 12 x 12 x 0.25 inches	HP 4204-0094

*Refer to Section VIII, Service, for applications.

**Utica Tool Company, Inc., Orangeburg, SC 29115 or the nearest Utica Tool Company distributor.

SECTION II
INSTALLATION

2-1. INTRODUCTION

This section provides the information needed to install the Power Meter. Included is information pertinent to the initial inspection, power requirements, line voltage and fuse selection, operating environment, instrument mounting, storage, and shipment.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers and panels).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The procedures for checking electrical performance are given in Section IV, Performance Tests. If the contents are incomplete, if there is a mechanical defect, or if the instrument does not pass the performance tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier and the Hewlett-Packard office. Keep the shipping material for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Power Requirements

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz. Leakage currents at these settings may exceed 3.5 mA.

The Power Meter requires a power source of any voltage between 90 and 126 Vac or between 198 and 252 Vac, 48 to 66 Hz, single phase. The Power Meter has the additional capability of operating with line frequencies of 360 to 440 Hz. However, operation at line frequencies greater than 66 Hz is limited to a line voltage of 90 to 126 Vac. The power consumption is less than 65 VA using either source.

WARNINGS

This is a Safety Class I product (i.e., provided with a protective earth terminal). An uninterruptible safety earth ground must be provided from the Mains power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and secured against any unintended operation.

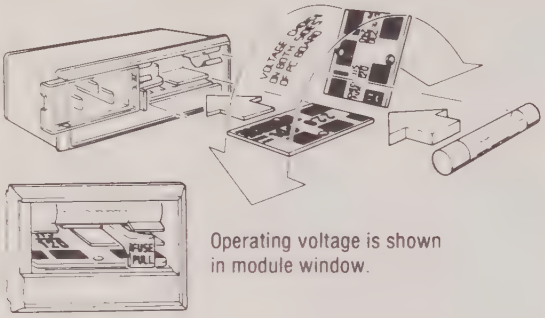
If the instrument is to be energized via an external autotransformer (for voltage reduction), make sure the common terminal is connected to neutral (that is, the grounded side of the mains supply).

2-5. Line Voltage and Fuse Selection

CAUTION

Before plugging this instrument into the Mains (line) voltage, be sure that the correct operating voltage and fuse have been selected.

A rear-panel line-power module permits operation from 90 to 126 Vac sources or from 198 to 252 Vac sources. The number visible in the window on the module indicates the nominal line voltage (100, 120, 220 or 240 Vac) to which the instrument must be connected. Verify that the line voltage selection card and the fuse are matched to the power source to be used. Refer to Figure 2-1, Line Voltage and Fuse Selection. Table 2-1 lists the ratings and HP part numbers for the replaceable fuses.



Operating voltage is shown in module window.

SELECTION OF OPERATING VOLTAGE

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left corner. Push the card firmly into the slot.
3. Rotate the FUSE PULL lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

Do not operate this instrument with frequencies greater than 66 Hz. Line frequencies greater than 66 Hz with line voltages greater than 126.5 Vac will cause a potential shock hazard that could result in personal injury (leakage current at these settings may exceed 3.5 mA). In addition, damage to the instrument may result.

Figure 2-1. Line Voltage and Fuse Selection

WARNING

For protection against fire hazards, the line fuse should be a 250V normal-blow fuse with the correct current rating.

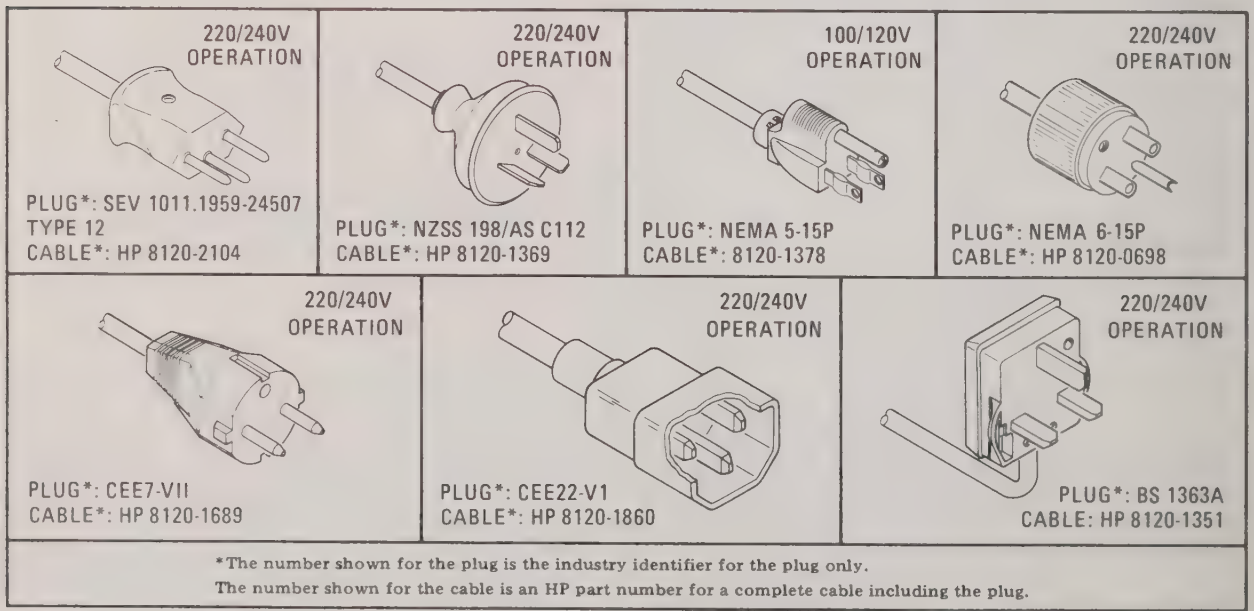
Table 2-1. Fuse Ratings and Part Numbers

Line Voltage	Rating	Part Number
100/120V	1.0A, 250V	2110-0001
220/240V	0.5A, 250V	2110-0012

2-6. Power Cable

WARNING

Before connecting this instrument, the protective earth terminal of the instrument must be connected to the protective conductor of the (Mains) power cord. The Mains plug shall be inserted only in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two-conductor outlet is not sufficient protection.



*The number shown for the plug is the industry identifier for the plug only.
The number shown for the cable is an HP part number for a complete cable including the plug.

Figure 2-2. Power Cable and Plug Part Numbers

Power Cable (cont'd)

This instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument is determined by the country of destination. Refer to Figure 2-2 for the part numbers of the power cables and plugs available.

Table 2-2. ASCII Address Codes to Decimal Equivalents

ASCII Address Codes		Decimal Equivalents
LISTEN	TALK	
SP	`	00
!	A	01
"	B	02
#	C	03
$	D	04
%	E	05
&	F	06
'	G	07
(	H	08
)	I	09
*	J	10
+	K	11
,	L	12
-	M	13
.	N	14
/	O	15
0	P	16
1	Q	17
2	R	18
3	S	19
4	T	20
5	U	21
6	V	22
7	W	23
8	X	24
9	Y	25
:	Z	26
;	[	27
<	\	28
=	]	29
>	^	30

Decimal 13 is the factory set HP 438A address.
Decimal 40—49 is TALK ONLY.
Decimal 50—59 is LISTEN ONLY.

2-7. HP-IB Address Selection

The address can be selected from the front panel and stored in RAM. The procedure for keying in an address from the front panel is to turn the instrument off, then press and hold the LCL (local) key while turning the instrument on, wait for the ENT (enter) address message,release the LCL key then key in the address using the keys representing the numbers. Table 2-2 shows the ASCII address codes to decimal equivalents.

When an address is stored in RAM and not lost, changing the internal HP-IB switch will have no effect. The internal HP-IB address switch is set at the factory to 13. The address that is stored in RAM can be viewed on the front panel display by pressing the LCL (local) key and will be the valid address unless memory is lost. Memory lost is indicated by a RCL (recall) FAIL ERROR message.

2-8. Interconnections

The connection from meter to power sensor is made through HP 11730A through F cables having circular 12 contact male mating connectors. The two front panel connectors (Sensor A and Sensor B), and the two rear panel Option 002 connectors (SENSORS A,B) require this mating connector.

The rear panel interface connector for the Hewlett Packard Interface Bus is a 24 pin connector. The HP-IB mating connector is shown in Figure 2-3. Part numbers for mating connectors are included in the figure. Note the two securing screws are metric.

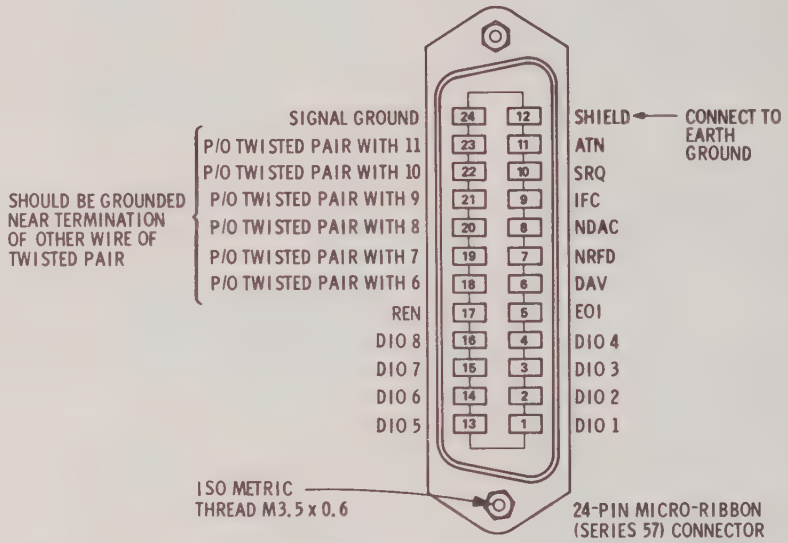
2-9. Mating Connectors

Coaxial Connectors. The front-panel output POWER REF 1.00mW 50 MHz and the rear-panel Option 002 OSC (power reference oscillator) output connectors require 50-ohm type N male mating connectors. The rear panel RCDR (recorder) output signal connector requires a 50-ohm BNC male mating connector. Both types must be compatible with the specifications of US MIL-C-39012. The power reference oscillator connectors are designed to be used with power sensors that have Type N connectors.

2-10. Operating Environment

The operating environment should be within the folloing limitations:

Temperature ..... 0°C to 55°C
Humidity ..... 40°C at <95% relative
Altitude ..... <4570 metres (15 000 feet)



Logic Levels

The Hewlett-Packard Interface Bus Logic Levels are TTL compatible, i.e., the true (1) state is 0.0 Vdc to +0.4 Vdc and the false (0) state is +2.5 Vdc to +5.0 Vdc.

Programming and Output Data Format

Refer to Section III, Operation.

Mating Connector

HP 1251-0293; Amphenol 57-30240.

Mating Cables Available

HP 10833A, 1 metre (3.3 ft), HP 10833B, 2 metres (6.6 ft)
HP 10833C 4 metres (13.2 ft), HP 10833D, 0.5 metres (1.6 ft)

Cabling Restrictions

1. A Hewlett-Packard Interface Bus system may contain no more than 2 metres (6.6 ft) of connecting cable per instrument.

2. The maximum accumulative length of connecting cable for any Hewlett-Packard Interface Bus system is 20.0 metres (65.6 ft).

Figure 2-3. Hewlett-Packard Interface Bus Connections

2-11. Bench Operation

The instrument cabinet has plastic feet and fold-away tilt stands for convenience in bench operation. The plastic feet are designed to ensure proper stacking with other instruments in similar housings, and the tilt stands raise the front of the Power Meter for easier viewing of the front panel.

2-12. Rack Mounting

The Power Meter may be rack mounted using Hewlett-Packard sub-module cabinets. If it is desired to rack mount one Power Meter by itself, order half-module kit, HP Part Number 5061-0072. If it is desired to rack mount two Power Meters or another HP product with the same physical dimensions, side by side, order the following items:

1) Lock Link Kit HP Part Number 5061-0094
2) Rack Mounting Flange Kit. HP Part Number 5061-0074

When rack mounting with a support shelf and slide kit order:

1) Shelf HP Part Number 5061-0096
2) Slide Kit HP Part Number 1494-0041

In addition to the rack mounting hardware, a front handle assembly (two provided) is also available for the Power Meter. Order front handle kit Option 907 HP Part Number 5061-0088.

Rack mounting information is provided with the rack mounting kits. If a kit was not ordered as an option or an accessory with the Power Meter, it may be purchased through the nearest Hewlett-Packard office. Refer to Mechanical Options or Mechanical Equipment Available in Section I.

2-13. STORAGE AND SHIPMENT

2-14. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment.

Temperature ..... −55°C to +75°C
Humidity ..... 40°C at <95% relative
Altitude ..... <15 300 metres (50 000 feet)

2-15. Packaging

Original Packaging. Containers and material identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument. Be sure to include the type of service required, return address, model number, and full serial number. Mark the container FRAGILE to assure careful handling. In any correspondence concerning a Hewlett-Packard instrument, refer to the instrument by model number and include the full serial number.

Other Packaging. The following general instructions should be followed for repackaging with commercially available packaging materials.

a. Complete one of the blue service tags located at the end of this manual and attach it to the instrument. Be sure to indicate the type of service required, return address, model number, and full serial number. Then wrap the instrument in heavy paper or plastic.

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 psi) test material is adequate.

c. Use enough shock absorbing material (75 to 100 mm or 3 to 4 inch layer) around bottom, top, and all sides to provide a firm cushion and to prevent movement within the container.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

SECTION III

OPERATION

3-1. INTRODUCTION

This section provides operating information for the Power Meter. Included in this section are general and detailed operating instructions, detailed descriptions of the front and rear panel, local and remote operator's checks, and operator's maintenance procedures.

3-2. Operating Characteristics

Table 3-1 briefly summarizes the major operating characteristics of the Power Meter. This table is not intended to be an in-depth listing of all operations and ranges but gives a rough idea of the instrument's capabilities. For more information on the power meters' capabilities refer to Table 1-1, Specifications and Table 1-2, Supplemental Characteristics. For information on HP-IB capabilities, refer to the summary contained in Table 3-5, HP-IB Message Reference Table.

3-3. Local Operation

Information covering front panel operation of the Power Meter is given in the sections described below. To rapidly learn the operation of the instrument, begin with Major Operating Characteristics and Operators' Checks.

Initial Turn-On Information. Instructions relating to the Power Meter's turn-on procedure are presented to acquaint the user with the general operation of the instrument.

Panel Features. Front and rear panel features are described in Figure 3-1 and 3-2.

Simplified Operating Functions. The instructions located on the foldout provide a quick introduction to front panel operation of the Power Meter. These instructions are designed to rapidly acquaint the new user with basic operating procedures and therefore are not an exhaustive listing of all Power Meter functions.

3-4. Remote Operation

HP-IB. The Power Meter is capable of remote operation via the Hewlett-Packard Interface Bus (HP-IB). Instructions pertinent to HP-IB operation cover considerations and instructions specific to remote operation including capabilities, addressing, input and

output formats, the status byte, and service requests. At the end of the discussion is a complete summary of all codes.

3-5. Operator's Checks

Operator's Checks are procedures designed to verify the proper operation of the Power Meter's main functions. Two procedures are provided as described below.

Basic Functional Checks. This procedure requires power sensors, cables, and a power splitter. It assures that most front panel controlled functions are being properly executed by the Power Meter.

HP-IB Functional Checks. These procedures require an HP-IB compatible computing controller, an HP-IB interface, and connecting cable. The procedures check the applicable bus messages summarized in Table 3-5. The HP-IB Checks assume that front panel operation has been verified by performing the Basic Functional Checks.

3-6. Operator's Maintenance

WARNING

> For continued protection against fire hazard, replace the line fuse with a 250V fuse of the same rating only. Do not use repaired fuses or short-circuited fuseholders.

Operator's maintenance consists of replacing defective fuses. The primary power fuse is located within the Line Power Module Assembly. Refer to Figure 2-1 for instructions on how to change the fuse.

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue tags located at the end of this manual and attach it to the instrument. Refer to Section II for packaging instructions.

3-7. TURN-ON INSTRUCTIONS

WARNINGS

Before the instrument is switched on, all protective earth terminals, extension cords, autotransformers and devices connected to it should be connected to a protective earth grounded socket. Any interruption of the protective earth grounding will cause a potential shock hazard that could result in personal injury.

Only 250V normal blow fuses with the required rated current should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

CAUTIONS

Before the instrument is switched on, it must be set to the voltage of the power source or damage to the instrument may result.

3-8. Turn-On

Turn-On Procedure. If the Power Meter is already plugged in, press the LINE switch to ON.

If the power cable is not plugged in, follow these instructions.

On the rear panel:

1. Check the line voltage switch for correct voltage selection.

2. Check that the fuse rating is appropriate for the line voltage used (see Figure 2-1). Fuse ratings are printed on the rear panel.

3. Plug in the power cable.

On the front panel, press the LINE switch to ON.

NOTE

Turn-On Configuration. The Power Meter turns on to the same control settings it had before line power was removed. An exception to this is that it always turns on in the local mode. In addition some HP-IB default conditions are enabled. Refer to "Turn on Default Conditions" later in this section.

When the Power Meter is turned on, it will execute a power up sequence which will be followed by an automatic RECALL 0. The power up sequence will run some self test routines to verify the operation of ROM, RAM, and display circuits. If any self test failures occur an error message will be reported to the user on the front panel display. If,for some reason, RAM content was lost this error will be reported and all storage registers initialized to put the meter into the PRE SET state. Storage location 0 is also set to the PRE SET state when a RAM error occurs. This means the meter will be in the PRE SET state when it begins operation. The internal HP-IB address switch is read only when the memory content is lost. In all other cases the HP-IB address that is entered from the front panel is the one saved in RAM.

NOTE

An internal battery is used to retain data in RAM during off peroids. The data restores the last control setup and the nineteen storage registers.

If a ROM or RAM failure occurs, the Power Meter will display an error code number in the range of 61 through 66. Table 3-2 lists and explains error codes.

3-9. Power Reference and Calibration

A POWER REF of 1.00 mW at 50 MHz is available at the front panel for calibrating the Power Meter to the sensor. The meter to sensor calibration is accomplished by connecting the sensor to the POWER REF output and pressing the ZERO key, pressing the CAL ADJ key, enter the reference calibration factor in percent, and press the ENTER key. The internal power reference is a 1 mW (0 dBm) 50 MHz oscillator that is factory set to +/- 0.7% and traceable to the National Bureau of Standards.

Table 3-1. Major Operating Characteristics

POWER RANGE	Auto or Manual 1 through 5 ranges -70 dBm to +40 dBm
	POWER SENSOR RANGE 8481B 0 to +44 dBm (1 mW to 25 W) 8482B 8481H -10 to +35 dBm (100 uW to 3 W) 8482H 8481A -30 to +20 dBm (1 uW to 100 mW) 8482A 8483A(75 Ohm) 8485A 8484A -70 to -20 dBm (100 pW to 10 uW)
FREQUENCY RANGE	100 kHz to 26.5 GHz
POWER DISPLAY	dBm, dB Relative, Watts, and % Relative
RATIO and DIFFERENCE	Dual Inputs Ratio in dB or % Difference in Watts or dBm
CALIBRATION FACTOR (1)	Compensation for mismatch and effective efficiency
OFFSET	Compensation for gains or losses in test system
ZEROING	Calibration of meter to power sensor sensitivity
POWER REFERENCE	1 mW at 50 MHz
DIGITAL FILTERING	Auto or Manual 0 through 9 ranges
MEMORY	19 registers for store and recall

(1) When using the 8483A Power Sensor, a special calibration procedure must be used. Instead of using a reference cal factor of 100% as may be indicated on the sensor's cal factor label, a value of 96% should be used. This is to compensate for the fact that the 8483A is a 75 Ohm sensor, and the reference oscillator has a characteristic impedance of 50 Ohms, causing a 4% mismatch error. By using a value of 96% instead of 100% for the ref cal factor, the mismatch error is compensated for. Newer 8483A Power Sensors will have the correct ref cal factor (96%) printed on the label.

SIMPLIFIED FRONT PANEL FEATURES

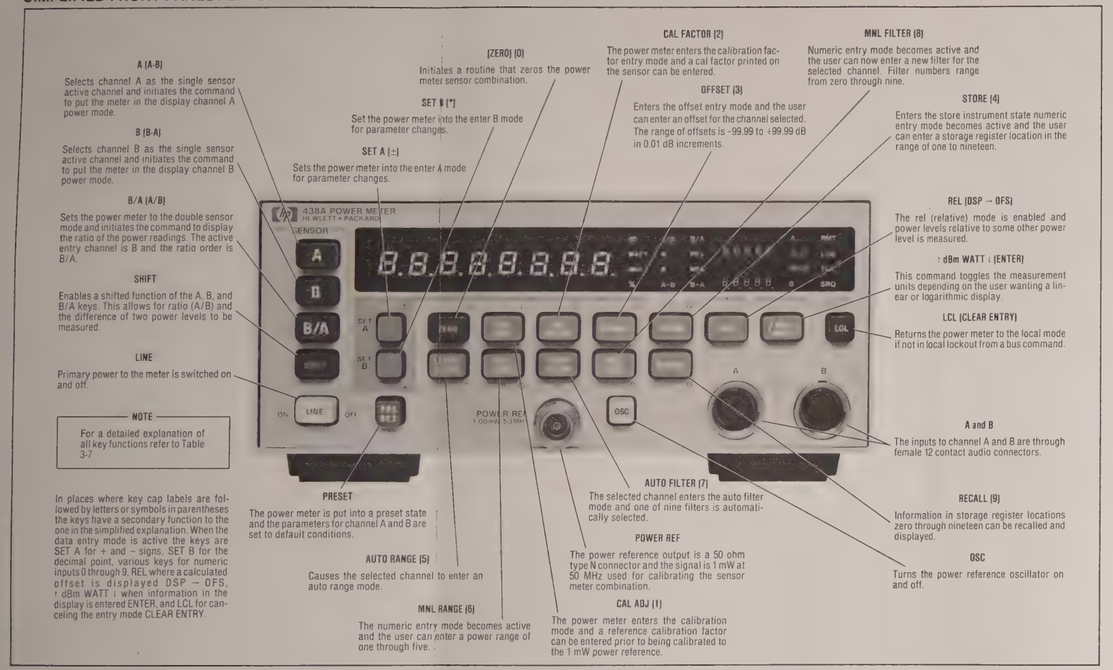
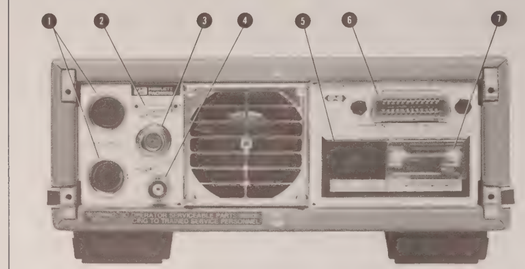

A (A-B)
Selects channel A as the single sensor active channel and initiates the command to put the meter in the display channel A power mode.
B (B-A)
Selects channel B as the single sensor active channel and initiates the command to put the meter in the display channel B power mode.
B/A (A/B)
Sets the power meter to the double sensor mode and initiates the command to display the ratio of the power readings. The active entry channel is B and the ratio order is B/A.
SHIFT
Enables a shifted function of the A, B, and B/A keys. This allows for ratio (A/B) and the difference of two power levels to be measured.
LINE
Primary power to the meter is switched on and off.
NOTE
For a detailed explanation of all key functions refer to Table 3-7
In places where key cap labels are followed by letters or symbols in parentheses the keys have a secondary function to the one in the simplified explanation. When the data entry mode is active the keys are SET A for + and − signs. SET B for the decimal point, various keys for numeric inputs 0 through 9. REL where a calculated offset is displayed DSP → OFS. ↑ dBm WATT ↓ when information in the display is entered ENTER, and LCL for canceling the entry mode CLEAR ENTRY.
(ZERO) (0)
Initiates a routine that zeros the power meter sensor combination.
SET B (.)
Set the power meter into the enter B mode for parameter changes.
SET A (±)
Sets the power meter into the enter A mode for parameter changes.
CAL FACTOR (2)
The power meter enters the calibration factor entry mode and a cal factor printed on the sensor can be entered.
OFFSET (3)
Enters the offset entry mode and the user can enter an offset for the channel selected. The range of offsets is -99.99 to +99.99 dB in 0.01 dB increments.
MNL FILTER (8)
Numeric entry mode becomes active and the user can now enter a new filter for the selected channel. Filter numbers range from zero through nine.
STORE (4)
Enters the store instrument state numeric entry mode becomes active and the user can enter a storage register location in the range of one to nineteen.
REL (DSP → OFS)
The rel (relative) mode is enabled and power levels relative to some other power level is measured.
↑ dBm WATT ↓ (ENTER)
This command toggles the measurement units depending on the user wanting a linear or logarithmic display.
LCL (CLEAR ENTRY)
Returns the power meter to the local mode if not in local lockout from a bus command.
A and B
The inputs to channel A and B are through female 12 contact audio connectors.
RECALL (9)
Information in storage register locations zero through nineteen can be recalled and displayed.
OSC
Turns the power reference oscillator on and off.
PRESET
The power meter is put into a preset state and the parameters for channel A and B are set to default conditions.
AUTO RANGE (5)
Causes the selected channel to enter an auto range mode.
MNL RANGE (6)
The numeric entry mode becomes active and the user can enter a power range of one through five.
CAL ADJ (1)
The power meter enters the calibration mode and a reference calibration factor can be entered prior to being calibrated to the 1 mW power reference.
POWER REF
The power reference output is a 50 ohm type N connector and the signal is 1 mW at 50 MHz used for calibrating the sensor meter combination.
AUTO FILTER (7)
The selected channel enters the auto filter mode and one of nine filters is automatically selected.
438A POWER METER
HEWLETT-PACKARD
SENSOR
A
B
B/A
SET A
SET B
LINE
OSC
A
B

Figure 3-1. Simplified Front Panel Features



1 SENSORS A B

Option 002 rear panel inputs to channel A and B are through 12 contact female audio connectors. Inputs are in parallel with front panel channel A and B.

2 Serial Number Plate

First four digits and letter constitute the prefix which defines the instrument configuration. The last five digits form a sequential suffix that is unique to each instrument. The plate also indicates any options supplied with the instrument

3 OSC

Option 002 rear panel 1 mW power reference output from the added oscillator. Output connector is a 50 ohm type N.

4 RCDR

BNC connector with an analog 0 to 1 volt signal that is related to power level measured by the meter. Output impedance is 1k ohm.

5 Line Power Module

Permits operation from 100, 120, 220, or 240 Vac The number visible in the window indicates nominal line voltage to which the instrument must be connected. The center conductor is safety earth ground.

6 HP-IB Connector

Female connector with 24 contacts used to connect the power meter to Hewlett-Packard Interface Bus (HP-IB) for remote operation.

7 Fuse

1.0A 250V for 100/120 Vac operation and 500 mA 250V for 220/240 Vac operation. Ordering information is presented in Section II, Installation.

Figure 3-2. Rear Panel Features

SIMPLIFIED OPERATING FUNCTIONS

PRESET

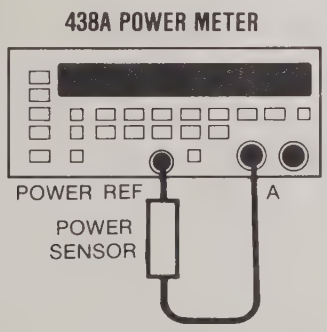
Press | PRE SET | to set the Power Meter to the following conditions:

- Measurement Mode = Sensor A
- Reference Oscillator = Off
- Active Entry Channel = SET A
- Measurement Units = Watts
- REL Mode = Off
- Measurement Parameters (set for Sensor A and Sensor B)
  - Cal Factor = 100%
  - Offset = 0.00 dB
  - Auto Filter
  - Auto Range

In addition, default conditions are set for some remote-only functions. Refer to Table 3-7, Response to a Clear Message (and PRESET).

CALIBRATION

Connect the power sensor to the Power Meter as shown:



Press | ZERO | to zero the Power Meter. Each sensor must be zeroed separately for dual sensor operation.

Filter

A digital filter averages measurement readings to reduce noise. A filter number (0 through 9) is entered to set the filter length. The filter length the number of readings averaged and is equal to 2 to the factor of the filter number (that is, from 1 to 512 in factors of 2).

AUTO FILTER	selects the optimum filter length automatically.

Because of speed, resolution, and noise considerations, the filter can be set manually. Measurements with higher filter numbers are slower and quieter; measurements with lower filter numbers are faster and noisier. For example, to manually set the filter to 7 (filter length of 128), press

MAN FILTER	AUTO FILTER	7	ENTER dBm WATT

Range

The Power Meter divides the sensor's power range into five ranges of 10 dB each. Range 5 may be less than 10 dB if the sensor has a power range of less than 50 dB. Range 1 is the most sensitive, and Range 5 is the least sensitive.

AUTO RANGE	sets the optimum range automatically.

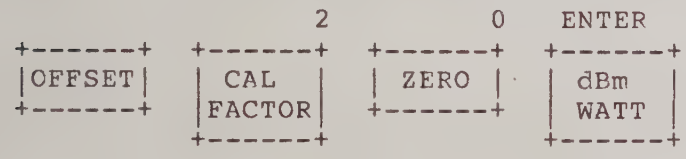
Manual range is used primarily with the rear panel recorder output or when faster readings are required (no time is lost due to auto ranging). For example, to set the range manually to Range 3, press

MNL RANGE	OFFSET	3	ENTER dBm WATT

MEASUREMENT PARAMETERS (cont'd)

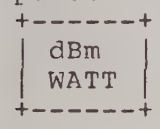
OFFSET

Offsets can be added to measurements to compensate for gain or loss in the measurement system. For example, to set an offset of 20 dB, press



MEASUREMENT UNITS

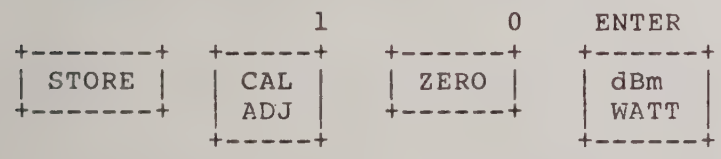
Power measurements are displayed in units of Watts or dBm. If relative mode is active, measurements are displayed in either percent or dB. Press



to toggle from one measurement unit to another.

STORE and RECALL

The Power Meter can store up to 19 instrument configurations for recall at a later time. For example, to store an instrument configuration in storage register 10, press



recalls an instrument configuration stored in register 3 and changes the Power Meter to the recalled parameters.

Table 3-2. Error Codes

The possible error states of the Power Meter are listed.

Error Code Number		
Channel		
A	B	
01	02	ZEROING ERROR: meter cannot zero selected sensor
03	04	NO REF CALIBRATION MESSAGE: the sensor is not connected to the reference oscillator or no output from oscillator
05	06	CALIBRATION ERROR: meter cannot calibrate selected sensor
11	12	INPUT OVERLOAD ERROR: input power exceeds the maximum allowed
15	16	PLEASE 0 A/D Underflow: input to A/D is below it's range
17	18	UP RANGE ERROR: input power is too high for the current range
31	32	NO SENSOR ERROR: a sensor is not connected to a selected channel
33	34	TWO SENSORS ERROR: both the front and rear sensor inputs have sensors connected
25		CALC OF OVERFLOW ERROR: power calculations resulted in a value which is to large to calculate or display
26		CALC UF UNDERFLOW ERROR: power calculations resulted in a value which is to small to calculate or display
27		LOG ERROR: Illegal logarithmic operation
28		REL ERROR: A valid data point to store as a reference has not been read

ENTRY ERRORS:

50 cal factor: the number entered is outside the range of allowed cal factors

51 offset: the number entered is outside the range of allowed offsets

52 range: the number entered is outside the range of allowed power ranges

53 filter: the number entered is outside the range of allowed filter values

54 rcl: the number entered is outside the range of valid rcl/sto registers

55 sto: the number entered is outside the range of valid rcl/sto registers

56 ref cf: Reference calibration factor outside of range

58 add: the number entered as an HP-IB address is outside the range of valid HP-IB addresses

57 RCL FAIL ERROR: RAM content has been lost because of a low battery or if the power meter was powered down incorrectly

90 BUS ERROR: Illegal number entered over the bus

91 BUS ERROR: Illegal command entered over the bus

POWER UP ERROR MESSAGES

61 ROM address 8000H-09FFFH: A3U9

62 ROM address 0A000H-0BFFFH: A3U9

63 ROM address C000-DFFF: A3U10

64 ROM address E000-FFFF: A3U10

65 RAM address 8000-0FFF: A3U12

66 RAM address 0-7FF: A3U13

ZEROING ERROR This error occurs when the meter is attempting to zero and one of the following occurs:

the input power is not zero

the input power changes during the attempt to zero

If the ZERO command is received during the zeroing process, either with or without an error having occured, the zeroing routine is aborted and the meter is put in its previous state. All other commands abort the zeroing routine and the function of the command received is executed.

CALIBRATION MESSAGE This message occurs when the instrument is put into calibrate mode and it detects that the sensor is not connected to the reference oscillator. To calibrate to an external reference the user should enter a negative reference cal factor when asked for the reference cal factor.

CALIBRATION ERROR This error occurs when the meter is attempting to calibrate and one of the following occurs:

the input power is not the correct reference power

the input power changes during the attempt to calibrate

The error message will remain until a command is received. The CAL ADJ command will abort the calibration routine and return the meter to its previous state. All other commands will abort the calibration process and the meter will execute the function of that command.

NO SENSOR ERROR This error occurs when the channel being read does not have a sensor connected.

To clear the error the user can either connect a sensor to the channel in error or switch to the other channel.

OVER RANGE ERROR This error occurs when the input power exceeds the maximum power for range 5 and only when the meter is on range 5. The error will occur when the input power is greater than 120% of the full scale power of range 5.

This error is cleared when conditions are such that the error no longer applies.

UNDER RANGE ERROR: This error occurs when the meter is in dBm, dB, or % mode and the input power is so low that calculating the power to display would result in an illegal mathematical operation. For example, an input of 0.00 nW with the meter in dBm mode results in the calculation of the logarithm of zero (0). In this case the error will occur.

The error is cleared when conditions are such that the error no longer applies.

A/D UNDERFLOW This error occurs when the input power is below the range of the A/D converter. In this case the meter should be rezeroed or input power checked.

This error is cleared when conditions are such that the error no longer applies.

UP RANGE ERROR This error occurs when the input power exceeds the maximum power for ranges 1, 2, 3, and 4 in HOLD RANGE mode. When the input power is greater than 120% of the full scale power for the range the meter is on, the UP RANGE error occurs.

The error is cleared when conditions are such that the error no longer applies.

TWO SENSORS ERROR This error occurs when the active channel has a sensor connected to both the front and rear sensor connectors.

To clear the error the user can either switch to the other channel or remove one of the two sensors connected to the channel in error.

OVERFLOW ERROR This error occurs when the combination of the input power, offset, cal factor, and measurement mode results in a value whose absolute value is greater than 3.4028E+38.

To clear the error the user should change one of the above parameters to bring the power calculation within the allowed range.

UNDERFLOW ERROR This error occurs when the combination of the input power, offset, cal factor, and measurement mode results in a value whose absolute value is less than 1.1755E-38.

To clear the error the user should change one of the above parameters to bring the power calculation within the allowed range.

ILLEGAL CAL FACT This error occurs when the user enters a cal factor outside the allowed range. The allowed range for cal factors is 1.0% to 150.0%. An illegal cal factor error occurs when entries greater than 150.0 or less than 1.0 are made. Entries such as 90.37 will be truncated to 90.3 and no error will occur.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the cal factor remains unchanged from it's previous value.

ILLEGAL OFFSET This error occurs when the user enters an offset outside the allowed range for offsets. The allowed range is +/-99.99. The illegal offset error occurs when entries greater than 99.99 (or less than -99.99) are made. Entries such as 5.028 will be truncated to 5.02.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the offset remains unchanged from it's previous value.

ILLEGAL RANGE This error occurs when the user enters a range outside the allowed range for power ranges. The allowed values are 1, 2, 3, 4, and 5.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the range remains unchanged from it's previous value.

ILLEGAL FILTER This error occurs when the user enters a filter number outside the range of allowed filter numbers. The allowed values are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the filter remains unchanged from its previous value. Note: This error can only occur over the bus since there is no way of inputing an illegal entry from the front panel.

CANNOT REL This error occurs when the user trys to enter REL mode while there is not a valid reading to store as the reference power.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed.

ILLEGAL STO/RCL This error occurs when the user enters a store or recall register number outside the range of valid register numbers. The valid range for store registers is 1-19 and the valid range for recall registers is 0-19.

The error is cleared after 2 seconds or when any other command is received. The function of the command received is executed.

ILLEGAL REF CAL FACT This error occurs when the user enters a ref cal factor outside the allowed range. The allowed range for ref cal factors is 50.0% to 120.0%. An illegal cal factor error occurs when entries greater than 120.0 or less than 50.0 are made. Entries such as 90.37 will be truncated to 90.3 and no error will occur.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the ref cal factor remains unchanged from its previous value.

ADDRESS ERROR This error occurs when the user enters an HP-IB address outside the allowed range of HP-IB addresses. The allowed range is 0-31,40-49, and 50-59. Anything outside of this range will cause an error condition.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed.

RCL FAIL This error occurs when the meter is turned on and the internal RAM content has been lost. This would generally be due to a run down battery, but may also occur if the meter is powered down during the end of a zero or calibration sequence.

The error is cleared after 2 seconds or by receiving any other command. The function of the command received is executed. When the error is cleared the meter is configured in a preset state. In this condition the HP-IB address is read from the internal address switch.

3-11. OPERATOR'S CHECKS

Operator's checks are simple procedures designed to verify that the main functions of the Power Meter operate properly. Two procedures are provided, one for basic (front panel) functional checks and the other for HP-IB functional checks.

BASIC FUNCTIONAL CHECKS

DESCRIPTION The operation of the Power Meter is checked using power sensors, sensor cables, and a power splitter. It provides reasonable assurance that most of the front panel controlled functions are being executed by the Power Meter.

EQUIPMENT

Power Sensors (2)	HP 8480 Series
Sensor Cables (2)	HP 11730 Series
Power Splitter	HP 11667A
Adapter	HP 1250-1528

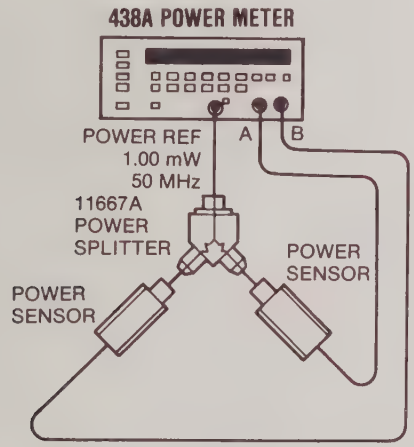


Figure 3-3. Simplified Operator's Check Setup

PROCEDURE

1. Turn on the Power Meter and observe the power up routine with nothing connected to the inputs. During power up the diagnostics stored in ROM are executed under microprocessor control and enable the display to flash all segments of the LED's, all letters, and symbols. Followed by a shorter flash of all dashes, before the final display of WATT A or B, 100 % or last cal factor entered, and channel

A or B. Since the Power Meter stores the last active parameters in storage location 0 this stored information is what will be recalled and displayed during power up consequently the reason for the "A" or "B" information being displayed.

2. Verify that the power up internal diagnostics are exercised without any error messages other than no CH A, ERROR 31 or no CH B, ERROR 32 depending on which channel was active during power down.

3. Press PRESET this sets the parameters for channel A and B to:

Cal Factor = 100.0%
Offset = 0.00 dB
Low Limit = 0.00 dB
High Limit = 0.00 dB
Auto Filter
Auto Range

and the meter is set to the following conditions:

Display Sensor A
Reference Oscillator is OFF
Enter A Mode
Watts Mode
Limits Checking is OFF
Rel Mode is OFF
Group Execute Trigger Mode (GT2)
Meter in Free Run Mode

4. Connect a power sensor with associated cable to channel A input. Error message should disappear and display will show some power level, with annunciators WATT A, 100 % CF, and A on.

5. Connect power sensor to 1 mW POWER REF display shows some power level.

6. Press ZERO, wait for zeroing routine to finish approximately 15 seconds (time varies depending on filter and range being used),
display shows --------, with walking decimal point. Observe that the POWER REF OSC LED is off during this routine.

7. Press CAL ADJ display shows Ent ----, annunciators %, 100.0 % CF A, and rcF are on.
Enter REF CAL FACTOR shown on power sensor using blue numeric keys and the SET B key for a decimal point then press ENTER. Wait for the CAL ADJ routine approximately 10 seconds (time varies depending on filter and range being used). Display shows --------, with walking decimal point and A, A. Observe that during CAL ADJ the POWER REF OSC LED will be turned off and on.

8. Press CAL FACTOR displays shows Ent ----, %, 100.0 % CF A, and 1-150.
Enter reference cal factor. If the CF is the same as the one entered in the preceding step just press ENTER and the CF displayed will be the one used in the measurements.

9. Display will now show 1.000 -3, with annunciators WATT, A, MNL, 100.0 % CF, and A on.

10. Press dBm WATT display shows a change to 0.00 dBm.

11. Press B and repeat steps 3 through 8 for channel B inputs.

12. Remove sensor from POWER REF OSC and connect the equipment as shown in Figure 3-x.

13. Display shows some power level. Annunciators WATT B, MNL, 100.0 % CF and B are on.

14. Press dBm WATT to display dBm. Display will now show the loss through the power splitter. This number will be used as an offset to get the power level displayed back to 1 mW. Annunciators A, MNL, 100.0 % CF, and A are on. Press B and the annunciators will change to display channel B information.

15. Press A then press OFFSET. Display shows Ent ----, annunciators show dB, 0.00 A, and <= 99.99.
Key in a number equivalent to power loss through power splitter using blue keys representing the numbers and the SET B key for the decimal point then press ENTER.

16. Repeat step 15 for channel B.

17. Press B/A, press dBm WATT to display ratio in %.

18. Note: several combinations of keys can be exercised at this time to further familiarize yourself with the front panel operation.

3-12. HP-IB Functional Checks

DESCRIPTION: These procedures check the Power Meter's ability to process or send the HP-IB messages described in Table 3-5. Only the Power Meter, a power sensor, a controller, and an HP-IB interface are needed to perform these checks.

These procedures do not check that all the Power Meter program codes are being properly interpreted and executed by the instrument. However, if the power-up sequence and front panel operation is good, the program codes, in all likelihood, will be correctly implemented.

The validity of these checks is based on the following assumptions:

a. The Power Meter performs properly when operated via the front panel keys (that is, in local mode). This can be verified by the Basic Functional Checks in this section.

b. The bus controller properly executes HP-IB operations.

c. The bus controller's interface properly executes the HP-IB operations.

If the Power Meter appears to fail any of these HP-IB checks, the validity of the above assumptions should be confirmed before attempting to service the instrument.

The select code of the controller's HP-IB interface is assumed to be 7. The address of the Power Meter is assumed to be 13 (its address set at the factory). This particular select code-address combination (that is, 713) is not necessary for these checks to be valid. However, the program lines presented here must be modified for any other combination.

These checks can be performed together or separately. Any special requirements for a check are described at the beginning of the check.

INITIAL SETUP: The test setup is the same for all of the checks. Connect the equipment as shown in Figure 3-4.

EQUIPMENT: HP-IB Controller.....HP-85F/82903A(16K Memory Module)/00085-15005(Advanced Programming ROM)

--or---

HP 9826A Option 011 (BASIC 2.0 ROM based system)

HP-IB Interface.....HP 82937A (HP-85F)

Power Sensor.....HP 848x series

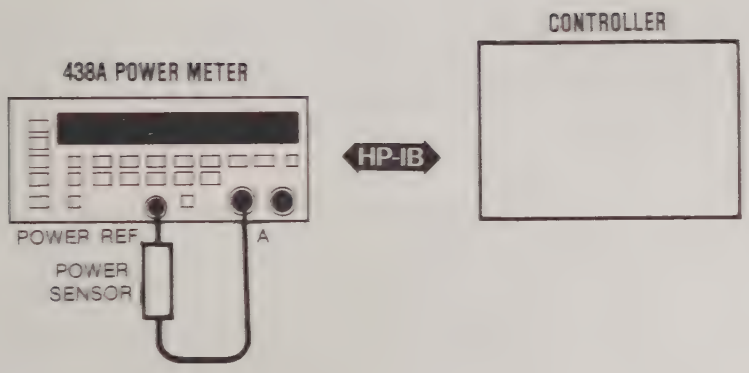


Figure 3-4. HP-IB Functional Checks Setup

Remote and Local Messages and LCL Key

NOTE: This check determines whether or not the Power Meter properly switches from local to remote control, from remote to local control, and whether or not the LCL key returns the instrument to local control. Before beginning this check, set the LINE switch to OFF, then to ON.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send the Remote message (by setting the Remote Enable bus control line, REN, true and and addressing the Power Meter to listen).	REMOTE 713	REMOTE 713

OPERATOR'S RESPONSE: Check that the Power Meter's RMT and LSN annunciators are on.

Send the Local message to the Power Meter	LOCAL 713	LOCAL 713

OPERATOR'S RESPONSE: Check that the Power Meter's RMT annunciator is off but its LSN annunciator is on.

Send the Remote message to the Power Meter.	REMOTE 713	REMOTE 713

OPERATOR'S RESPONSE: Check that both the RMT and LSN annunciators are on. Press the LCL key on the Power Meter. Check that the RMT annunciator is now off, but that the LSN annunciator remains on.

Sending the Data Message

NOTE: This check determines whether or not the Power Meter properly issues Data messages when addressed to talk. Before beginning this check, set the Power Meter's LINE switch to OFF, then to ON. Press PRESET and set the manual filter to 9. (If an HP 9826A controller is used, a short program is required to perform this check.)

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Address the Power Meter to talk and store its output in variable V.	ENTER 713;V	10 V=0 20 ENTER 713;V
Display the value of V.	DISP V	30 DISP V 40 END

OPERATOR'S RESPONSE: Check that the Power Meter's TLK annunciator is on. The controller should display the same value as the one shown in the Power Meter's display. Note that the Power Meter displays data using engineering notation. The controller may display the same value using a different format.

Receiving the Data Message

NOTE: This check determines whether or not the Power Meter properly receives Data messages.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send the first part of the Remote message (enabling the Power Meter to remote).	REMOTE 7	REMOTE 7
Address the Power Meter to listen (completing the Remote message), then send a Data message.	OUTPUT 713; "KB 95 EN"	OUTPUT 713; "KB 95 EN"

OPERATOR'S RESPONSE: Check that the Power Meter's RMT and LSN annunciators are on and that the display shows a Cal Factor of 95%.

Local Lockout and Clear Lockout/Set Local Messages

NOTE: This check determines whether or not the Power Meter properly receives the Local Lockout message, disabling all front panel keys (including LCL). This check also determines whether or not the Clear Lockout/Set Local message is properly received and executed by the Power Meter. This check assumes the Power Meter is in remote mode.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send the Local Lockout message.	LOCAL LOCKOUT 7	LOCAL LOCKOUT 7

OPERATOR'S RESPONSE: Check that the RMT annunciator is on. Press the Power Meter's LCL key. The RMT annunciator should remain on.

Send the Clear Lockout/Set Local message.	LOCAL 7	LOCAL 7

OPERATOR'S RESPONSE: Check that the Power Meter's RMT annunciator is off.

Return the Power Meter to remote mode if the remaining checks in this section are to be performed.	REMOTE 713	REMOTE 713

OPERATOR'S RESPONSE: Check that the Power Meter's RMT annunciator is on.

Clear Message

NOTE: This check determines whether or not the Power Meter properly resonds to the Clear Message. This check assumes that the Power Meter is in remote mode.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send a Data message to set the cal factor to 98.5%.	OUTPUT 713; "KB 98.5 EN"	OUTPUT 713; "KB 98.5 EN"

OPERATOR'S RESPONSE: Check that the Power Meter's display indicates the channel A cal factor is set to 98.5%.

Send the Clear message (setting the cal factor to 100%).	CLEAR 713	CLEAR 713

OPERATOR'S RESPONSE: Check that the Power Meter's display indicates the channel A cal factor is set to 100%.

Abort Message

NOTE: This check determines whether or not the Power Meter becomes unaddressed when it receives the Abort message. This check assumes the Power Meter is in remote mode.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Address the Power Meter to listen.	OUTPUT 713	OUTPUT 713

OPERATOR'S RESPONSE: Check that the Power Meter's LSN annunciator is on.

Send the Abort message, unaddressing the Power Meter from listening.	ABORTIO 7	ABORT 7

OPERATOR'S RESPONSE: Check that the Power Meter's LSN annunciator is off.

Status Byte Message

NOTE: This check determines whether or not the Power Meter sends the Status Byte message. Before beginning this check, set the Power Meter's LINE switch to OFF then to ON and press PRESET.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Place the Power Meter in serial-poll mode (causing it to send the Status Byte message).	SPOLL(713)	SPOLL(713)

OPERATOR'S RESPONSE: Check that the controller's display reads 0.

Require Service Message

NOTE: This check determines whether or not the Power Meter can issue the Require Service Message (set the SRQ bus control line true). This check can be performed in either local or remote mode.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send a Data message to set the Request Mask to 4.	OUTPUT 713 USING "2A,B"; "@1",4	OUTPUT 713 USING "2A,B"; "@1",4
Send a Data message containing an entry error. This causes a Require Service message to be sent.	OUTPUT 713; "RM 15 EN"	OUTPUT 713; "RM 15 EN"

OPERATOR'S RESPONSE: Check that the Power Meter's SRQ annunciator is on. (If an HP 9826A controller is being used, a short program is required to perform this portion of the check.)

Read the binary status of the controller's HP-IB interface and store the data in variable V (in this step, 7 is the interface's select code, and 2 (HP-85) and 7 (HP 9826A) are status registers for bus control lines).	STATUS 7,2;V	10 V=0 20 STATUS 7,7; V
Display the value of the SRQ bit (in this step, 6 (HP-85) and 10 (HP 9826A) are the SRQ bits for the controller, numbered from 0).	DISP "SRQ="; BIT(V,6)	30 DISP "SRQ =";BIT(V,10) 40 END

OPERATOR'S RESPONSE: Check that the SRQ value is 1, indicating that the Power Meter issued the Require Service message.

Status Bit Message

NOTE: This check determines whether or not the Power Meter sends the Status Bit message. This check can be performed in either local or remote mode. If the Power Meter's SRQ annunciator is off, perform the first part of the Require Service message check before beginning this check.

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Configure the Power Meter to respond to a parallel poll with positive-true logic on HP-IB data line DIO3.	SEND 7;LISTEN 19 CMD 5 SCG 10	PPOLL CONFIGURE 713; 10
Place the Power Meter in parallel poll mode (causing it to send the Status Bit message).	PPOLL(7)	PPOLL(7)

OPERATOR'S RESPONSE: Check that the SRQ annunciator is on and that the response to the parallel poll is 4, indicating that the Power Meter issued the Status Bit message.

Unconfigure the Power Meter from responding to a parallel poll.	SEND 7; LISTEN 19 CMD 5 SCG 18	PPOLL UNCONFIGURE 713
Place the Power Meter in parallel poll mode.	PPOLL(7)	PPOLL(7)

OPERATOR'S RESPONSE: Check that the SRQ annunciator is on and that the response to the parallel poll is 0, indicating that the Power Meter is no longer configured to respond to a parallel poll. Set the LINE switch to OFF, then to ON, to turn off the SRQ annunciator.

Trigger Message

NOTE: This check determines whether or not the Power Meter responds to a Trigger message. This check assmumes that the Power Meter is in remote mode. (If an HP 9826A is used as the controller, a short program is required to perform this check.)

Description	HP-85 (BASIC)	HP 9826 (BASIC)
Send a Data message to place the Power Meter in the Trigger Hold mode.	OUTPUT 713; "TR0"	10 OUTPUT 713; "TR0"
Send the Trigger message.	TRIGGER 713	20 TRIGGER 713
Address the Power Meter to talk and store the data in variable V.	ENTER 713;V	30 V=0 40 ENTER 713;V
Display the value of V.	DISP V	50 DISP V 60 END

OPERATOR'S RESPONSE: Check that the Power Meter's RMT and TLK annunciators are on and that the controller displays the same value as the one shown in the Power Meter's display. (Note that the Power Meter displays data using engineering notation. The controller may display the same value using a different format.)

Table 3-5. Message Reference Table (1 of 3)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions
Data	Yes	All Power Meter operations, (except setting the LINE switch and setting the HP-IB address) and remote-only functions are bus programmable. All measurement results are available to the bus.		AH1 SH1 T5 TE0 L4 LE0
Trigger	Yes	The Power Meter's response to bus command GET can be programmed. The default condition is Trigger with Delay (GT2). If in remote and addressed to listen, the Power Meter makes a measurement according to previously programmed set-up.	GET	DT1
Clear	Yes	The Power Meter is set to the same conditions as established by PRESET. Refer to Table 3-6.	DCL SDC	DC1
Remote	Yes	Remote mode is enabled when the REN bus control line is true. Remote mode is not entered, however, until the first time the Power Meter is addressed to listen. The front panel RMT annunciator lights when the instrument is actually in remote mode. When entering remote mode, no instrument settings or functions are changed but all front panel keys, except LCL, are disabled.	REN	RL1

Table 3-5. Message Reference Table (2 of 3)

HP-IB Message	Applicable	Response	Related Commands and Controls	Interface Functions
Local	Yes	The Power Meter returns to local mode (front panel control). It responds equally to the Go To Local (GTL) bus command and the front panel LCL key.	GTL	RL1
Local Lockout	Yes	Disables all front panel keys, including LCL. Only the controller can return the Power Meter to local (front panel control).	LLO	RL1
Clear Lockout/ Set Local	Yes	The Power Meter returns to local mode (front panel control) and local lockout is cleared when the REN bus control line goes false.	$\overline{\text{REN}}$	RL1
Pass Control/ Take Control	No	The Power Meter has no controller capability.		C0
Require Service	Yes	The Power Meter sets the SRQ bus line true if one of the following conditions exists and it has been enabled by the Service Request Mask to send the message for that condition: data ready, cal/zero completed, entry error, measurement error, and over/under limits.	SRQ	SR1

Table 3-5. Message Reference Table (3 of 3)

HP-IB Message	Appli-cable	Response	Related Commands and Controls	Inter-face Func-tions
Status Byte	Yes	The Power Meter responds to a Serial Poll Enable (SPE) bus command by sending an 8-bit byte when addressed to talk. If the instrument is holding the SRQ control line true (issuing the Require Service message), bit 7 in the Status Byte and the bit representing the condition causing the Require Service message to be issued will both be true. The bits in the Status Byte are latched but can be cleared by removing the causing condition and then reading the Status Byte or by receiving the Clear Status (CS) program code.	SPE SPD	T5
Status Bit	Yes	The Power Meter responds to a Parallel Poll Enable (PPE) bus command by sending a bit on a controller selected HP-IB data line.	PPE PPD PPC PPU	PP1
Abort	Yes	The Power Meter stops talking and listening.	IFC	T5 TE0 L4 LE0

Commands, control lines, and interface functions are defined in IEEE Std 488-1978. Knowledge of these may not be necessary if your controller's manual describes programming in terms of the twelve HP-IB Messages shown in the left column.

Complete HP-IB capability as defined in IEEE Std 488-1978 and ANSI Std MC1.1 is SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, DT1, AND C0.

3-13. REMOTE OPERATION, HEWLETT-PACKARD INTERFACE BUS

The Power Meter can be operated through the Hewlett-Packard Interface Bus (HP-IB). HP-IB is Hewlett-Packard's implementation of IEEE Standard 488 and the identical ANSI Standard MC1.1. Bus compatibility, programming, and data formats are described in the following paragraphs.

All front panel functions (except that of the LINE switch and HP-IB address entry) are programmable via HP-IB. The SHIFT key is not programmable because the shifted functions have their own program codes. Additional functions are available in remote operation only.

A quick test of the Power Meter's HP-IB interface is described in this section under HP-IB Functional Checks. These checks verify that the Power Meter can respond to or send each of the applicable bus messages described in Table 3-5.

For more information about HP-IB, refer to IEEE Std 488 (or the identical ANSI Standard MC1.1), the Hewlett-Packard Electronic Systems and Instruments catalog, and the booklet "Improving Measurements in Engineering and Manufacturing" (HP part number 5952-0058).

3-14. HP-IB Compatibility

The Power Meter's complete bus compatibility as defined by IEEE Std 488 (and the identical ANSI Standard MC1.1) is described at the end of Table 3-5. Table 3-5 also summarizes the Power Meter's HP-IB capabilities in terms of the twelve messages in the "HP-IB Message" column.

3-15. Remote Mode

Remote Capability. The Power Meter communicates on the bus in both remote and local modes. In remote, most of the Power Meter's front panel keys are disabled (exceptions are the LINE switch and the LCL key). However, front panel displays remain active and valid. In remote, the Power Meter can be addressed to talk or listen. When addressed to listen, the Power Meter responds to the Data, Trigger, Clear (SDC), Remote, and Local messages. When addressed to talk, the Power Meter can issue the Data and Status Byte messages. Whether addressed or not, the Power Meter responds to the Clear (DCL), Local Lockout, Clear Lockout/Set Local, and Abort messages. In addition, the Power Meter may issue the Require Service and Status Bit messages.

Local-to-Remote Changes. The Power Meter switches to remote operation upon receipt of the Remote message. The Remote message has two parts:

a. remote enable bus control line (REN) set true, and

b. device listen address received once (while REN is true).

When the Power Meter switches to remote, the front panel RMT annunciator turns on. The Power Meter's control settings remain unchanged with the local-to-remote transition.

3-16. Local Mode

Local Capability. In local, the Power Meter's front panel controls are fully operational and the instrument will respond to to the Remote message. Whether it is addressed or not, it will also respond to the Clear, Local Lockout, Clear Lockout/Set Local, and Abort messages. When addressed to talk, the instrument can issue Data messages and the Status Byte message. Whether addressed or not, the instrument can issue the Require Service and Status Bit messages.

Remote-to-Local Mode Changes. The Power Meter always switches to local from remote whenever it receives the Local message (GTL) or the Clear Lockout/Set Local message. (The Clear Lockout/Set Local message sets the remote enable bus control line [REN] false.) If not in Local Lockout mode, the Power Meter switches to local from remote whenever the front panel LCL key is pressed.

Local Lockout. A local lockout is recommended for purely automatic applications. Local lockout disables the LCL key and allows return-to-local only under program control.

NOTE

Return-to-local can also be accomplished by setting the Power Meter's LINE switch to OFF, then to ON. However, this technique has some disadvantages:

a. It defeats the purpose and advantage of local lockout (that is, the system controller loses control of a system element).

b. There are several HP-IB conditions that reset to default states at turn-on.

3-17. Addressing

The Power Meter interprets the byte on the eight HP-IB data lines as an address or a bus command if the bus is in the command mode. The command mode is defined as attention control line (ATN) true and interface clear control line (IFC) false. Whenever the Power Meter is addressed (whether in local or remote), either the TLK or LSN annunciator on the front panel turns on.

The Power Meter's HP-IB address is set in decimal from the front panel. HP-IB address switches (set in binary) are located inside the instrument. The only time the Power Meter reads the internal switches, however, is when the internal RAM contents storing the front panel address setting have been lost (for example, when the battery fails).
Additional information for setting the internal switches is located in Sections II and VIII.

The Power Meter's HP-IB address can be set from the front panel as follows:

a. Set Power Meter's LINE switch from OFF to ON while pressing and holding the LCL key.

b. Release the LCL key.

c. Enter the desired HP-IB address in decimal (0-30) and then press the ENTER key.

To display the current HP-IB address setting in the front panel display, press and hold the LCL key.

Listen Only Mode. The Power Meter is placed in Listen Only mode when its HP-IB address is set to 40.
The Listen Only mode is provided to allow the Power Meter to accept programming from devices other than controllers.

Talk Only Mode. The Power Meter is placed in Talk Only mode when its HP-IB address is set to 50. In this mode, the instrument is configured to send Data messages whenever the bus is in the data mode (attention control line [ATN] false).

3-18. Turn-on Default Conditions

Several HP-IB parameters are reset at turn-on. The parameters and their default conditions are listed below.

HP-IB Local Mode

Unaddressed

Service Request Mask cleared

Status Byte cleared

Free Run Trigger Mode

GT2 (Trigger with Delay) response to Trigger message

Parallel Poll data line unassigned

Display Enable active

3-19. Data Messages

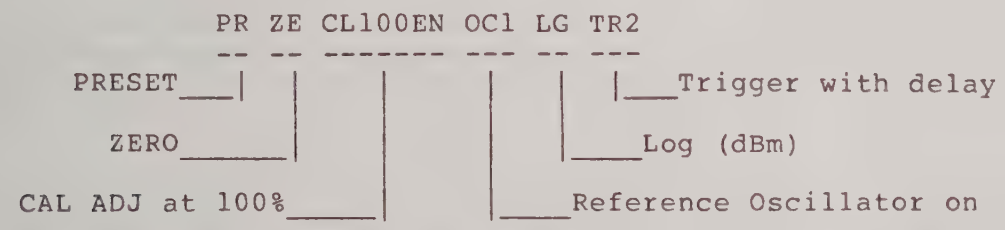
The Power Meter communicates on the interface bus primarily with Data messages. Data messages consist of one or more bytes sent over the bus' data lines when the bus is in the data mode (ATN bus control line false). Unless it is set to Talk Only, the Power Meter receives Data messages when addressed to listen. Unless it is set to Listen Only, the Power Meter sends Data messages or the Status Byte message when addressed to talk. Virtually all instrument operations available in local mode can be performed in remote mode via Data messages. The only exceptions are changing the LINE switch and changing the HP-IB address. In addition, the Power Meter may be triggered via Data messages to make measurements at a particular time.

3-20. Receiving the Data Message

The Power Meter responds to Data messages when it is enabled to remote (REN bus control line true) and it is addressed to listen. The instrument remains addressed to listen until it receives its talk address, an Abort message, or a universal unlisten command.

Data Input Format. The Data message string, or program string, consists of a series of ASCII codes. Each code is typically equivalent to a front panel keystroke in local mode. Thus, for a given operation, the program string syntax in remote mode is the same as the keystroke sequence in local mode. Example 1 shows a typical program string.

EXAMPLE 1: Typical Program String ----------



Program Codes. All of the HP-IB codes normally used by the operator to control the Power Meter are given in Table 3-9, HP-IB Code to Parameter Summary. All front panel keys except LCL/CLEAR ENTRY and SHIFT have corresponding program codes. Lower case alpha characters are interchangeable with upper case characters. The number 0 and the letter O are not interchangeable.

Numeric data can be entered in fixed, floating point, or exponential format. All numeric entries must be terminated with the program code "EN" (this is equivalent to pressing the ENTER key in local mode).

Turning Off Functions. When operating in local mode, OSC (reference oscillator) and REL (relative mode) toggle on and off with successive keystrokes. In remote mode, these functions do not toggle on and off. Instead, a specific program code is required to turn off each function. Use RL0 to turn off REL mode and OC0 to turn off the reference oscillator.

Range Hold. When the Power Meter is addressed to listen and receives program code RH (Range Hold), it switches from auto range to manual range using the current range value. If the Power Meter is already in manual range mode no action is taken. No range number is entered with this program code.

Filter Hold. When the Power Meter is addressed to listen and receives program code FH (Filter Hold), it switches from auto filter mode to manual filter mode using the current filter value. If the Power Meter is already in manual filter mode no action is taken. No filter number is entered with this program code.

Limits. The limits checking function allows the Power Meter to monitor the power present at each sensor and indicate when that power is outside preset limits. Enabling the limits checking function and setting limit values is available only via remote programming.

A high limit and a low limit can be set for each sensor. To set the the limits for a sensor, address the Power Meter to listen and then send a Data message consisting of program code LL (low limit) or LH (high limit), a numeric value, and program code EN (ENTER). The allowable range for limit values is --299.999 to +299.999. Values entered that are outside of this range cause the limit to be set to the minimum or maximum value as appropriate. The low limit can be set to a value greater than the high limit and the high limit can be set to a value less than the low limit. Limit values are entered in dBm and converted automatically to Watts when necessary.

The limits checking function is enabled by program code LM1 and disabled by program code LM0. When the limits checking function is enabled, it uses the last values set for the high and low limits. PRESET (and the Clear message) sets both the high and low limits for Sensors A and B to 0.000 dBm and disables the limits checking function.

If the limits checking function is enabled and the input power exceeds the high limit or is less than the low limit, the condition is indicated on the front panel as well as over the bus. The out-of-limits condition is indicated on the front panel by the flashing A and/or B annunciator. The out-of-limits

condition is indicated only for the sensor(s) used by the current measurement mode. The out-of-limits condition can be indicated over the bus by setting the Service Request Mask to enable an out-of-limits condition to issue the Require Service message. This condition can also be indicated by reading the Status Message.

Display Functions. The selection of display functions is available only via remote programming. During local operation, the Power Meter display is enabled to indicate measurement results, error codes, entries in progress, and instrument status. In remote mode, two additional display functions are allowed: display disable and display all.

Display Enable (DE). This function is identical to local operation and is the function in effect when no other display function has been selected. This is the display function at turn-on. This condition is also established by PRESET and the Clear message.

Display Disable (DD). This function blanks out the front panel display. All readings over the bus remain valid. This function is cleared by sending another display function program code (DA or DE), by PRESET, or by the Power Meter receivng the Clear message.

Display All (DA). This function causes the Power Meter to turn on all front panel display LED segments. It is used to verify that all display segments are working properly. This function is cleared by sending another display function program code (DE or DD), by PRESET, or by the Power Meter receiving the Clear message. (At turn-on, all the display segments light momentarily before the display enable becomes active.)

Triggering Measurements with the Data Message. A feature that is only available via remote programming is the selection of free run, standby, or triggered operation of the Power Meter. During local operation the Power Meter is allowed to free run, outputting data to the display as each measurement is completed. In remote, three additional operating modes are allowed: hold, trigger immediate, and trigger with delay.

Hold (TR0). This mode is used to set up triggered measurements (initiated by program codes TR1, TR2, and the Trigger message). In hold mode, internal settings can be altered by the instrument itself or by the user via the bus. The instrument, however, is inhibited from outputting any data to the front panel display or to the HP-IB except as follows. The instrument will issue the Status Byte message if serial polled.

Upon leaving hold, the front panel display is updated as the new measurement cycle begins. The Status Byte will be affected by the events that occur during the new measurement cycle. The Power Meter leaves hold mode when it receives either the free run, trigger immediate, or trigger with delay program codes, or the

Trigger message, or when it returns to local mode via the LCL key.

Trigger Immediate (TR1). When the Power Meter receives the trigger immediate program code, it makes one measurement in the shortest possible time. The instrument then waits for the measurement results to be read. While waiting, the instrument can process most bus commands without losing the measurement results. However, if the instrument receives GET (Group Execute Trigger), a new measurement cycle will be executed. Once the data (measurement results) are read onto the bus, the Power Meter reverts to the hold mode. Measurement results obtained via trigger immediate are normally valid only when the instrument is in a steady, settled state.

Trigger with Delay (TR2). Triggering with delay is identical to trigger immediate except the Power Meter inserts a settling-time delay before taking the requested measurement. This settling time is a function of the selected range and filter and is sufficient to produce valid, accurate measurement results.

Free Run (TR3). This mode is identical to local operation and is the mode of operation in effect when no other trigger mode has been selected. The measurement result data available to the bus is constantly being updated as rapidly as the Power Meter can make measurements. Entry into remote from local via the LCL key sets the Power Meter to the free run mode. (A local command from the controller does not return the Power Meter to free run mode.)

Program Order Considerations. Although program string syntax is virtually identical to keystroke order, some program order considerations need highlighting.

Trigger Immediate and Trigger with Delay. When either of the trigger program codes TR1 or TR2 is received by the Power Meter, a measurement is immediately initiated. Once the measurement is completed, some bus commands can be processed without aborting the measurement. However, any HP-IB program code sent to the Power Meter before the triggered measurment results have been completed will abort the trigger. Thus, trigger codes should always appear at the end of a program string, and the triggered measurement results must be completed before any additional program codes that affect measurement are sent.

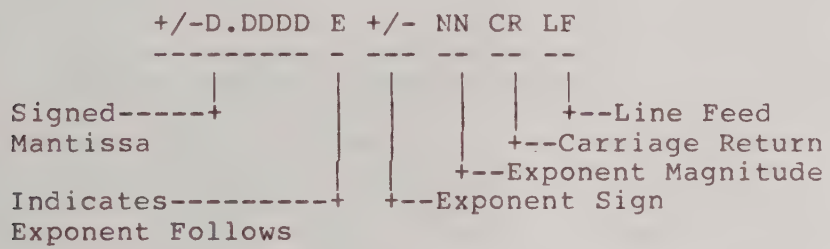
ZERO and CAL ADJUST. Zero the Power Meter before performing a calibration adjustment to avoid inaccurate measurement results.

OFFSET and Display Offset. The display offset program code (DO) is only valid when it follows the program code for OFFSET (OS). When the Power Meter is addressed to listen and receives the program string "OS DO EN" (a Data message), the offset that causes the Power Meter display to read 0 dB is entered.

3-21. Sending the Data Message

The Power Meter can send Data messages when addressed to talk. The instrument remains configured to talk until it is unaddressed to talk by the controller. To unaddress the Power Meter, the controller must send the Power Meter's listen address, a new talk address, an Abort message or a universal untalk command.

Data Output Format. As shown below, the output data is usually formatted as a real constant in exponential form: first the sign, then a digit, a decimal point, and five digits followed by the letter E and a signed power-of-ten multiplier. The string is terminated by a carriage return (CR) and line feed (LF). The Power Meter sends an EOI with the last byte of each output string.



When an error is output to the bus, it follows the same format described above. As long as the front panel display indicates an error condition, the Power Meter sends 9.0000E+40 as the measured data when addressed to talk. To determine the error code, it is necessary to read the Status Message. Refer to the Status Message paragraph below for additional information.

Exceptions to this format are the data output for the following functions:

Learn Mode #1

Learn Mode #2

Status Message

Identification

Service Request Mask Value

Each of the above five functions is enabled by first addressing the Power Meter to listen. Then the Power Meter must receive a Data message with the appropriate program code. When the Power Meter is addressed to talk, it will output data for the selected function. The output format for these functions is described in the following paragraphs. Service Request Mask Value is explained later under Sending the Service Request Mask Value.

Learn Modes. In addition to being able to store front panel setups in its own registers, the Power Meter has two learn modes that use the controller's memory. One learn mode allows the Power

Meter to send instrument configurations to the controller's memory. The second learn mode is a subset of the first and transfers only information that can be stored in a STORE/RECALL register.

Whenever data is being transferred between controller and Power Meter, it must do so in uninterrupted strings. If a data string is broken or interrupted, the data could be lost or offset, and misinterpreted by the Power Meter. An offset of data bytes can persist until EOI is read.

Learn Mode #1. After receiving an LP1 program code (Learn Mode #1) and when addressed to talk, the Power Meter sends a string of up to 128 ASCII characters containing information on the instrument configuration. The last character is sent with with EOI bus line true, thus terminating the message. This data can then be stored in the controller's memory for future use.

When the Power Meter is addressed to listen, the ASCII data string can be returned to the Power Meter. The Power Meter changes accordingly. Table 3-6 shows the information contained in the string and the order in which it is sent.

Table 3-6. Learn Mode #1 Output Format

Parameter	Output From Power Meter*
Trigger Mode	TRx
Measurement Mode	AP, BP, AR, BR, AD, or BD
Sensor A Parameters	AE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	LH sxxx.xxx EN
Sensor B Parameters	BE
Cal Factor	KB xxx.x EN
Offset	OS sxx.xx EN
Range	RA or RM x EN
Filter	FA or FM x EN
Low Limit	LL sxxx.xxx EN
High Limit	LH sxxx.xxx EN
Active Entry Channel	AE or BE
Measurement Units	LG or LN
Reference Oscillator Status	OC0 or OC1

Group Trigger Mode	GTx
Limits Checking Status	LM0 or LM1
EOI	Carriage Return-Line Feed
* s indicates sign; x indicates a single digit	

Learn Mode #2. After receiving the program code LP2 (Learn Mode #2) and when addressed to talk, the Power Meter sends 2 ASCII characters, @ and 2, followed by a string of 28 8-bit binary bytes. The last byte is sent with EOI bus line true, thus terminating the message. This binary data can then be stored in the controller's memory.

The most straight-forward way to program the system controller is to use a loop to read 30 binary characters and store them in an array. Learn Mode #2 requires a controller that can transfer information in binary form.

This string contains the following information:

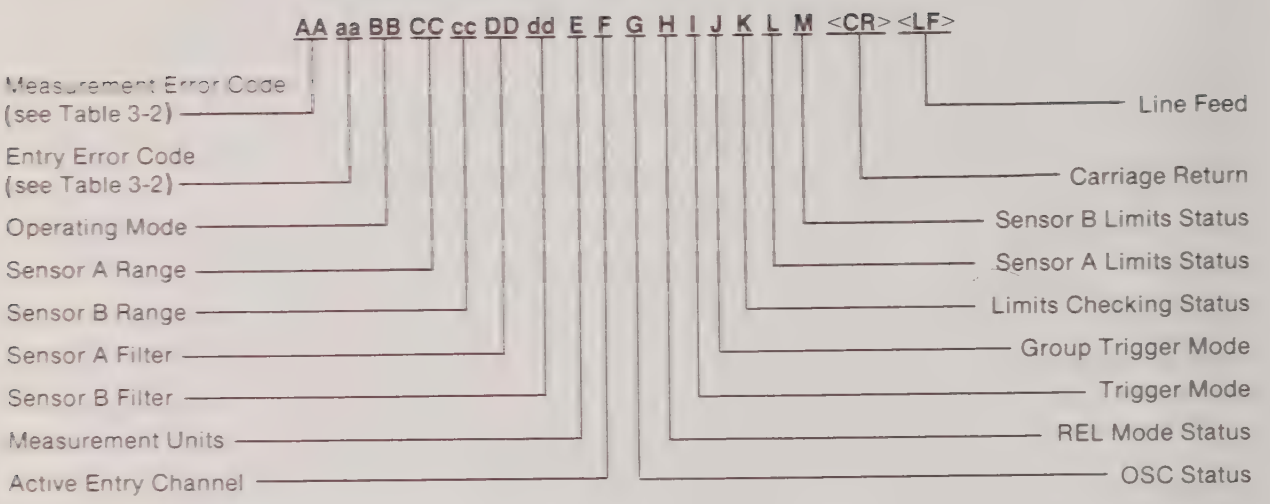
- Measurement mode
- REL mode status (on or off)
- Reference oscillator status (on or off)
- Active entry channel (A or B)
- Current reference value if in REL mode
- Meausrement units (Log or Lin)
- Cal Factor for each sensor
- Offset for each sensor
- Range for each sensor
- Filter for each sensor

When the Power Meter is addressed to listen, the binary data can be returned to the Power Meter. The Power Meter changes accordingly.

Status Message. This function enables the Power Meter's current state to be read under program control. After receiving an SM program code (Status Message) and when addressed to talk, the Power Meter sends a string of 23 ASCII characters followed by carriage return (CR), line feed (LF), and EOI. The Status Message can be interpreted with the information shown in Figure 3-5.

Identification. This function is used to identify the the Power Meter's model number and the firmware version. After receiving a ?ID program code and when addressed to talk, the Power Meter sends the following string: HP438A,VERX.XX. HP438A is the instrument model number and VERX.XX is the firmware version number.

Status Message



BB	CC cc	DD dd	E	F	G	H	I	J	K	L M
Operating Mode	Range	Filter	Measure-ment Units	Active Entry Channel	OSC Status	REL Mode Status	Trigger Mode	Group Trigger Mode	Limits Checking Status	Sensor A & B Limits Status
00=Sensor A 01=Sensor B 02=A/B 03=B/A 04=A-B 05=B-A 06=Zeroing A 07=Zeroing B 08=Calib-rating A 09=Calib-rating B 10=Exter-nal Cal A 11=Exter-nal Cal B	Manual Range 01=1 02=2 03=3 04=4 05=5 Auto Range 11=1 12=2 13=3 14=4 15=5	Manual Filter 00=0 01=1 02=2 03=3 04=4 05=5 06=6 07=7 08=8 09=9 Auto Filter 10=0 11=1 12=2 13=3 14=4 15=5 16=6 17=7 18=8 19=9	0=Watts 1=dBm 2=% 3=dB	A=A B=B	0=Off 1=On	0=Off 1=On	0=Free Run 1=Hold	0=GT0 1=GT1 2=GT2	0=Disabled 1=Enabled	0=In limits 1=Over high limit 2=Under low limit 3=Over high limit and under low limit

Figure 3-5. Status Message Information

3-22. Receiving the Clear Message

The Power Meter responds to the Clear message by assuming the same conditions as established by PRESET. Refer to Table 3-7. The Power Meter responds equally to the Selected Device Clear (SDC) bus command when addressed to listen, and the Device Clear (DCL) bus command whether addressed or not.

Table 3-7. Response to a Clear Message (and PRESET)

Parameter	Condition
Sensor A	
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Sensor B	
CAL FACTOR	100.0%
OFFSET	0.00 dB
Filter	AUTO
Range	AUTO
Low Limit	0.000 dBm
High Limit	0.000 dBm
Display	Sensor A
OSC	Off
Entry Channel	SET A
Measurement Units	WATT
Limits Checking	Off
REL	Off
Trigger Mode	Free Run
Group Execute Trigger Mode	GT2
Display Function	Display Enable

3-23. Receiving the Trigger Message

When in remote and addressed to listen, the Power Meter responds to a Trigger message (the Group Execute Trigger bus command [GET]) by executing one of the pre-programmed codes shown in Table 3-8. If none of the codes has been pre-programmed (via a

Data message), the Power Meter responds to the Trigger message by executing one settled-measurement cycle (GT2), which is the default condition at turn-on. Refer to Triggering Measurements with the Data Message, discussed earlier in this section.

Table 3-8. Response to a Group Execute Trigger

Program Code	Power Meter Response
GT0	Ignore Group Execute Trigger
GT1	Trigger Immediate (TR1)
GT2	Trigger with Delay (TR2)

3-24. Receiving the Remote Message

The Remote message has two parts. First, the remote enable bus control line (REN) is held true, then the device listen address is sent by the controller. These two actions combine to place the Power Meter in remote mode. Thus, the Power Meter is enabled to go into remote when the controller begins the Remote message, but it does not actually switch to remote until addressed to listen the first time. No instrument settings are changed by the transition from local to remote. When actually in remote, the Power Meter lights the front panel RMT annunciator.

3-25. Receiving the Local Message

The Local message is the means by which the controller sends the Go To Local (GTL) bus command. If addressed to listen, the Power Meter returns to front panel control when it receives the Local message. If the instrument was in local lockout when the Local message was received, front panel control is returned, but lockout is not cleared. Unless it receives the Clear Lockout/Set Local message, the Power Meter will return to local lockout the next time it goes to remote. No instrument settings are changed by the transition from remote to local.

When the Power Meter goes to local mode, the front panel RMT annunciator turns off. However, when the Power Meter is being addressed (whether in local or remote), its front panel LSN or TLK annunciator lights.

3-26. Receiving the Local Lockout Message

The Local Lockout message is the means by which the controller sends the Local Lockout (LLO) bus command. If in remote, the Power Meter responds to the Local Lockout message by disabling the front panel LCL key. The local lockout mode prevents loss of system control due to someone accidentally pressing front panel keys. If, while in local, the Power Meter is enabled to remote (that is, REN set true) and it receives the Local Lockout message, it will switch to remote mode with local lockout the first time it is addressed to listen. When in local lockout, the Power Meter can be returned to local only by the controller

(using Local or Clear Lockout/Set Local messages) or by setting the LINE switch to OFF and back to ON or by removing the bus cable.

3-27. Receiving the Clear Lockout/Set Local Message

The Clear Lockout/Set Local message is the means by which the controller sets the Remote Enable (REN) bus control line false. The Power Meter returns to local mode (full front panel control) when it receives the Clear Lockout/Set Local message. When the Power Meter goes to local mode, the front panel RMT annunciator turns off.

3-28. Receiving the Pass Control Message

The Power Meter does not respond to the Pass Control message because it cannot act as a controller.

3-29. Sending the Require Service Message

The Power Meter sends the Require Service message by setting the Service Request (SRQ) bus control line true. The instrument can send the Require Service message in either local or remote mode. When the Power Meter is sending the Require Service message, the front panel SRQ annunciator lights. The Require Service message is cleared when a serial poll is executed by the controller or when a "CS" (clear status) program code is received via a Data message.

There are five conditions that can be enabled to cause the Require Service message to be sent. These conditions are described below.

Data Ready: when the Power Meter has a data point requested by a trigger command.

Cal/Zero Completed: when the Power Meter has completed a calibration or zeroing cycle.

Entry Error: when a number is entered that is out of the allowable range for the selected parameter.

Measurement Error: when the power applied to the sensors is incorrect for the current instrument configuration.

Over/Under Limits: when the limits checking function is enabled and the measured power is greater than the high limit or lower than the low limit.

Service Request Mask. The Service Request Mask determines which bits can set the Status Byte's RQS bit true (see Figure 3-6). When the RQS bit is true, the SRQ bus line is also true.

The Service Request Mask is set by the program code "@1" followed by an 8-bit byte (a Data message). The value of the byte is determined by summing the weight of each bit to be checked. Each bit, if true, enables the corresponding condition to set the RQS bit true. At turn-on, the Service Request Mask is cleared (that is, set to 0).

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Condition	0	RQS Bit Require Service	0	Over/ Under Limit	Measurement Error	Entry Error	Cal/ Zero Complete	Data Ready

Figure 3-6. The Status Byte and Service Request Mask

Sending the Service Request Mask Value (a Data Message). After receiving an RV program code (Service Request Mask value) and when addressed to talk, the Power Meter will send a single binary word (8 bits) that describes the present state of the mask. The bit pattern can be interpreted with the information in Figure 3-6.

NOTE

This byte is sent with the bus EOI line true, thus terminating the message.

3-30. Sending the Status Byte Message

After receiving a Serial Poll Enable (SPE) bus command and when addressed to talk, the Power Meter sends the Status Byte message. The Status Byte message consists of one 8-bit byte in which five of the bits are set according to the conditions described under Sending the Require Service Message. The bit pattern of the Status Byte is shown in Figure 3-6. Note that bits 6 and 8 are always set to 0. The remaining bit is the RQS bit.

If one or more of the five conditions described above is both present and enabled by the Service Request Mask, the bits corresponding to the the conditions and also bit 7, the RQS bit, are set true (and the Require Service message is sent). If one or more of the five conditions occurs but has not been enabled by the Service Requst Mask, the corresponding bits are still set true. However, if a condition has not been enabled by the mask, it cannot cause the RQS bit to be set true.

Once the Power Meter receives the serial poll enable (SPE) bus command, it is no longer able to alter the status byte. If a bit has been enabled and that condition occurs after the RQS bit has

been set true, the bit is stored in a buffer and is read the next time the Power Meter receives the SPE bus command.

After the Status Byte message has been sent, it will be cleared if the Serial Poll Disable (SPD) bus command is received, if the Abort message is received, or if the Power Meter is unaddressed to talk. Bits stored in the buffer waiting to be read, however, are not cleared. Regardless of whether or not the Status Byte message has been sent, the Status Byte and any Require Service message pending will be cleared if a Clear Status (CS) program code is received by the Power Meter.

3-31. Sending the Status Bit Message

The Power Meter sends the Status Bit message (if configured to do so) as part of the interface's response to the Parallel Poll Enable (PPE) bus command. In order for the Power Meter to respond to a PPE bus command, it must be assigned a single HP-IB data line on which to respond by the controller. The controller also assigns the logic sense of the bit. Both tasks are accomplished by the Parallel Poll Configure (PPC) bus command. If the Power Meter is sending the Require Service message, it will set its assigned status bit true. The Power Meter can send the Status Bit message without being addressed to talk.

The data line on which the Power Meter is assigned to respond is cleared by sending the Parallel Poll Unconfigure (PPU) bus command. At turn-on, the data line is unassigned.

3-32. Receiving the Abort Message

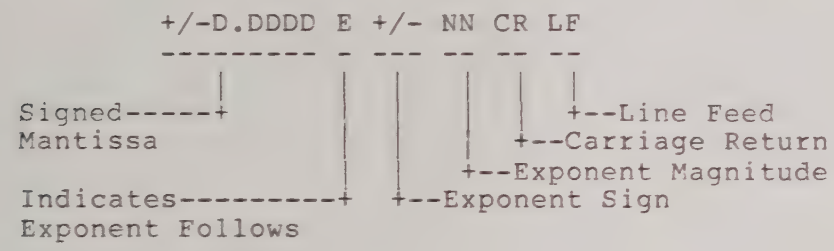
The Abort message is the means by which the controller sets the Interface Clear (IFC) bus control line true. When the Abort message is received, the Power Meter becomes unaddressed and stops talking and listening.

HP-IB SYNTAX AND CHARACTERISTICS SUMMARY

Address:
Set in decimal from the front panel. Set the LINE switch to ON while pressing the LCL key. Release the LCL key, enter the desired address, and press the ENTER key.
Factory set to 13.

Data Input Format:
Typically the same as front panel keystrokes in local mode. All numeric entries sent over the HP-IB must be terminated with program code "EN" (for ENTER).

Data Output Format:
Output format when no other talk mode has been defined:



Output format for Learn Mode #1 (program code LP1):
Up to 128 ASCII characters [EOI]

Output format for Learn Mode #2 (program code LP2):
30 bytes [EOI]

Output format for Identification (program code ?ID):
HP438AVERx.xx [EOI]

Output format for Status Message (program code SM):
23 ASCII characters [EOI]

Output format for Service Request Mask Value (program code RV):
1 byte [EOI]

Return to Local:
Front panel LCL key if not locked out.

Status Byte:

Bit	8	7	6	5	4	3	2	1
Weight	128	64	32	16	8	4	2	1
Service Request Condition	0	RQS Bit Require Service	0	Over/ Under Limit	Measure-ment Error	Entry Error	Cal/ Zero Com-plete	Data Ready

Notes:
1. The condition indicated in bits 1-5 must be enabled by the Service Request Mask to cause a Service Request Condition. The mask is set with the @1 program code followed by an 8-bit byte. The value of the byte is determined by summing the weight of each bit to be checked.
2. The RQS bit (bit 7) is true when any of the conditions of bits 1-5 are enabled and occur.
3. Bits remain set until the Status Byte is cleared.

Complete HP-IB Capability (as described in IEEE Std 488-1978, and ANSI Std MC1.1): SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP1, DC1, C0.

Table 3-9. HP-IB Codes to Parameter Summary (1 of 3)

HP-IB Code*	Parameter
AD	Channel A minus Channel B measurement
AE	SET A
AP	Channel A measurement
AR	A/B ratio measurement
BD	Channel B minus Channel A measurement
BE	SET B
BP	Channel B measurement
BR	B/A ratio measurement
*CL	CAL ADJ
CS	Clear Status Byte
DA	Display All
DD	Display Disable
DE	Display Enable
DO	DSP->OFS
EN	ENTER
FA	AUTO FILTER
FH	Filter Hold
*FM	MNL FILTER
GT0	Ignore Group Execute Trigger (GET) bus command
GT1	Trigger Immediate response to Group Execute Trigger
GT2	Trigger with Delay response to Group Execute Trigger

Codes preceded by an asterisk (*) require numeric entry followed by program code EN. Do not enter the asterisk as part of the program code.

Table 3-9. HP-IB Codes to Parameter Summary (2 of 3)

HP-IB Code*	Parameter
*KB	CAL FACTOR
LG	Log (dB or dBm)
*LH	High Limit
*LL	Low Limit
LM0	Disable limits checking function
LM1	Enable limits checking function
LN	Linear (Watts or %)
LP1	Learn Mode #1
LP2	Learn Mode #2
OC0	Reference Oscillator off
OC1	Reference Oscillator on
*OS	OFFSET
PR	PRESET
RA	AUTO RANGE
*RC	RECALL
RH	Range Hold
RL0	Exit REL mode
RL1	Enter REL mode
*RM	MNL RANGE
RV	Service Request Mask Value

Codes preceded by an asterisk (*) require numeric entry followed by program code EN. Do not enter the asterisk as part of the program code.

Table 3-9. HP-IB Codes to Parameter Summary (3 of 3)

HP-IB Code*	Parameter
SM	Status Message
*ST	STORE
TR0	Trigger Hold
TR1	Trigger Immediate
TR2	Trigger with Delay
TR3	Trigger - Free Run
ZE	ZERO
@1	Prefix for Service Request Mask
?ID	Identification

Codes preceded by an asterisk (*) require numeric entry followed by program code EN. Do not enter the asterisk as part of the program code.

Table 3-10. Front Panel and HP-IB Command Descriptions

The following is a description of each command recognized by the Power Meter from the front panel or over HP-IB.

A — Set Power Meter into single sensor mode. REL mode is set to off. Channel A is the active channel. Storage location 0 is updated by this command. See RECALL for more information on storage location 0. This command puts the meter in the display channel A's power mode and sets the entry channel to A. The annunciator's on the right of the Power Meter show the cal factor and the offset for channel A. If there is not an offset (0.00 dB offset), the bottom small display will be blank and the dBOS annunciator will be off. The middle block of annunciators will indicate the power measurement mode and the measurement units. When the A power command is received the A annunciator is turned on and the A/B, B/A, A-B, B-A, and B annunciators are turned off. Either the WATT or dBm annunciator is turned on (dBm if in log mode, WATT otherwise) and the dB and % annunciators are off. Pressing this key causes the digital filter to be zeroed and started over.

A-B — Set Power Meter into double sensor mode and display the difference of the power readings. REL mode is set to off. The subtraction order is A-B. This function is accessed from the front panel by first pressing the SHIFT key and then pressing the A key. Pressing this key causes the digital filter to be zeroed and started over. Storage location 0 is updated by this command. This command puts the meter in the difference power mode and sets the entry channel to A. The annunciators on the right will be in one of the display configurations described under the B/A key.

The middle block of annunciators will indicate the power measurement mode and the measurement units. When the A-B command is received the A-B annunciator is turned on and the A/B, B/A, B-A, A, and B annunciators are turned off. Either the WATT or dBm annunciator is turned on (dBm if in log mode, WATT otherwise) and the dB and % annunciators are off.

A/B — Set Power Meter into double sensor mode and display the ratio of the power readings. REL mode is set to off. The ratio order is A/B. This function is accessed from the front panel by first pressing the SHIFT key and then pressing the B/A key. Pressing this key causes the digital filter to be zeroed and started over. Storage

location 0 is updated by this command. This command puts the meter in the ratio power mode and sets the entry channel to A. The annunciators on the right will be in one of the display configurations described under the B/A key.

The middle block of annunciators will indicate the power measurement mode and the measurement units. When the A/B command is received the A/B annunciator is turned on and the B/A, A-B, B-A, A, and B annunciators are turned off. Either the % or dB annunciator is turned on (dB if in log mode, % otherwise) and the dBm and WATT annunciators are off.

AUTO FILTER The selected channel enters the auto filter mode. If the meter is already in auto filter mode the meter's state does not change. Storage location 0 is updated by this command.

AUTO RANGE The selected channel enters auto range mode. If the meter is already in auto range mode pressing this key causes the meter to down range one range if possible. Since the meter is in auto range this will generally have no effect, but if the power reading is in the range such that the reading could be displayed on either range then the meter will stay on this range. This gives the user a way of down ranging to get higher precision when in border line situations. Storage location 0 is updated by this command.

B Set Power Meter into single sensor mode. REL mode is set to off. Channel B is the active channel. Storage location 0 is updated by this command. See RECALL for more information on storage location 0. This command puts the meter in the display channel B's power mode and sets the entry channel to B. The annunciators on the right of the Power Meter show the cal factor and the offset for channel B. If there is not an offset (0.00 dB offset), the bottom small display will be blank and the dBOS annunciator will be off. The middle block of annunciators will indicate the power measurement mode and the measurement units. When the B power command is received the B annunciator is turned on and the A/B, B/A, A-B, B-A, and A annunciators are turned off. Either the WATT or dBm annunciator is turned on (dBm if in log mode, WATT otherwise) and the dB and % annunciators are off. Pressing this key causes the digital filter to be zeroed and started over.

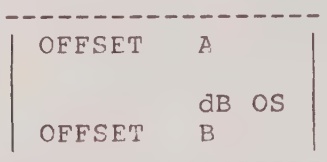
B-A Set Power Meter into double sensor mode and display the difference of the power readings. REL mode is set to

off. The subtraction order is B-A. This function is accessed from the front panel by first pressing the SHIFT key and then pressing the B key. Pressing this key causes the digital filter to be zeroed and started over. Storage location 0 is updated by this command. This command puts the meter in the difference power mode and sets the entry channel to B. The annunciators on the right will be in one of the display configurations described under the B/A key.

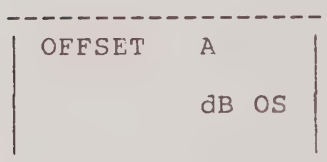
The middle block of annunciators will indicate the power measurement mode and the measurement units. When the B-A command is received the B-A annunciator is turned on and the A/B, B/A, A-B, A, and B annunciators are turned off. Either the WATT or dBm annunciator is turned on (dBm if in log mode, WATT otherwise) and the dB and % annunciators are off.

B/A

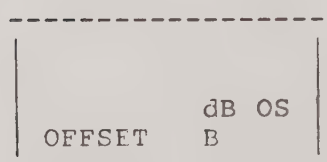
Set Power Meter into double sensor mode and displays the ratio of the power readings. REL mode is set to off. The ratio order is B/A. Pressing this key causes the digital filter to be zeroed and started over. Storage location 0 is updated by this command. This command puts the meter in the ratio power mode and sets the entry channel to B. The annunciators on the right will be in one of the display configurations described below:



If both channels have an offset present (non zero).



If A has a non zero offset and B has an offset of 0.



If B has a non zero offset and A has an offset of 0.

If neither channel has a

CAL FCT B	non zero offset present.

The middle block of annunciators will indicate the power measurement mode and the measurement units. When the B/A command is received the B/A annunciator is turned on and the A/B, A-B, B-A, A, and B annunciators are turned off. Either the % or dB annunciator is turned on (dB if in log mode, % otherwise) and the dBm and WATT annunciators are off.

CAL ADJ The Power Meter enters the calibration mode. The user may now enter the REF CAL FACTOR as printed on the sensor in use. The valid range for REF CAL FACTOR is 50% to 120%. Any thing outside this range will generate an error. If the user enters a negative REF CF, the meter will calibrate to an external reference source. If the entry is positive the meter first checks that the sensor is connected to the reference source by turning the reference oscillator on and off and watching for a power level change on the selected sensor. If the sensor is connected, then the reference oscillator is turned on for the calibration procedure and is returned to its former state upon completion of the calibration. The LED next to the OSC key indicates the state of the reference oscillator. If the sensor is not connected to the reference source, the calibration error message is displayed. (Refer to error messages for more information.) If the user presses the CLEAR ENTRY (LCL) key the calibration is aborted and the meter returns to its previous state. If the ENTER (dBm WATT) key command is received before any data is entered, the meter uses the previously defined reference cal factor. Any command received during the calibration process will abort the calibration and execute the function of the command received. (If the CAL command is received it will simply abort the calibration process.)

The calibration procedure does 3 things, sets the gain DAC, sets the analog output DAC, and finds scale factor to normalize the meter reading to 1.000. The reference cal factor is needed since all sensors are not 100% at 50 MHz. Offsets are ignored during the calibration. Because of the variety of sensor power ranges, the Power Meter will always auto range during calibration. It will then return to its previous mode after the calibration.

CAL FACTOR The Power Meter enters the cal factor entry mode. The user can now enter a new cal factor for the currently selected sensor. When this command is received the

numeric entry mode becomes active. If the CLEAR ENTRY (LCL) key is pressed the meter returns to its previous state without making any changes. The ENTER (dBm WATT) key command is used to enter the new cal factor. If the ENTER command is received before any data is entered, the cal factor is set to 100.0%. If the user presses the +/- (SET A) key, it is ignored. Front panel numeric entry accepts up to 4 digits. Any more entered are ignored. The decimal point (SET B) key is accepted once and placed to the right of the right most entered digit. If there are no digits displayed when the decimal point key is pressed the display will show a leading zero and only 1 more digit will be accepted. Any more decimal point key entries after the first are ignored. Entered digits are displayed starting in the left most position and progressing to the right until all four positions are full. No more than 1 digit will be accepted after the decimal point key is pressed in the front panel entry mode. From the bus the cal factor will be rounded to the required resolution. Storage location 0 is updated when a valid entry is made.

dBm WATT This command toggles the measurment units according to:

current units	new units
WATT	dBm
dBm	WATT
dB	%
%	dB

Storage location 0 is updated by this command.

LCL If the meter has not been put into local lock out mode by the bus this key returns the meter to local from remote and puts the meter into free run mode. The HP-IB address of the Power Meter is displayed when this key is pressed. As long as the LCL key is held down the HP-IB address is displayed. If the Power Meter is in talk only mode an address of 50 is shown as the address of the Power Meter. If the Power Meter is in listen only mode an address of 40 is shown as the address of the Power Meter.

LIMITS This function is only available over the bus and is used to allow the meter to monitor the power present at each channel and report when that power exceeds or is less than preset limits. These limits are input by the user over the bus. There are 2 limit values for each channel; a high limit and a low limit. If the input

power goes above the high limit the condition is indicated over the bus as well as on the front panel. The out of limits condition is indicated on the front panel by flashing the A or B annunciator for the appropriate channel. The same is true if the input power goes below the low limit. (Refer to HP-IB commands for more information.) The allowed range for limit values is -299.999 to 299.999. Values sent that are outside this range will cause the limit to be set to the maximum or minmum value as appropriate. The limits checking is only done if the limits checking function has been enabled over the bus.

MNL FILTER The numeric entry mode becomes active and the user can now enter a new filter for the selected channel. When a legal entry is made the meter switches to MNL FILTER mode. Storage location 0 is updated on a valid filter entry. The valid filter entries are 0 through 9. The +/- (SET A) and decimal point (SET B) keys are ignored. The CLEAR ENTRY (LCL) key returns the meter to the state it was in before the MNL FILTER command was entered. If the ENTER command is received before a filter number is entered, the meter returns to it's previous state except that it is in hold filter mode. This provides the user with a way to go from auto filter to hold filter mode and keep the meter on the same filter without entering a filter number. If the meter was already in hold filter mode before the MNL FILTER command was entered, using the ENTER command in this way does nothing but update storage location 0. Front panel filter entries accept one digit only. If a second digit is entered, it replaces the one that was there before.

Whenever a channel that is not in AUTO FILTER mode is being used in the power calculation, the MNL annunciator is lit.

MNL RANGE The numeric entry mode becomes active and the user can now enter a new range for the selected channel. When a valid entry is made, the meter goes to the entered range and switches to hold range mode. The storage location 0 is updated on valid completion of a range entry. The valid range entries are 1,2,3,4, and 5. All other entries result in a range entry error. The +/- (SET A) and decimal point (SET B) keys are ignored. The CLEAR ENTRY (LCL) key returns the meter to the state it was in before the MNL RANGE command was received. If the ENTER (dBm WATT) key command is received before any numeric data is entered the meter is returned to it's previous state except that it is in hold range mode. This provides the user with a way to go from auto range to hold range mode and keep the meter on the same range without

entering a range number. If the meter was already in hold range mode before the MNL RANGE command was received, this command does nothing but update storage location 0. Front panel range entries accept one digit only. If a second digit is entered, it replaces the one that was there before.

Whenever a channel that is not in AUTO RANGE mode is being used in the power calculation, the MNL annunciator is lit.

OFFSET The Power Meter enters the offset entry mode. The user can now enter a new offset for the channel selected. The numeric entry mode is active. Storage location 0 is updated when a valid entry is made. If the CLEAR ENTRY key is pressed the meter returns to its previous state without making any changes. The ENTER (dBm WATT) key command is used to enter the new offset. If the ENTER command is received before any data is entered, the offset is set to 0.00 dB. If the user presses the +/- (SET A) key, the sign of the entered offset changes. If the user presses the +/- key before any data is entered, the sign of any offset entered later is changed according to how many times the +/- key is pressed. (A minus sign will be displayed even when data hasn't been entered). Front panel offset entries are handled in the same manner as cal factor entries except that the +/- key is not ignored. No more than 2 digits will be accepted after the decimal point in front panel entry mode. From the bus the offset will be rounded to the required resolution. Note that offsets are added to the measured power. Example: measured power is 5 dBm, offset is 3 dB, the displayed power is 8 dBm.

There is another function active during offset entry. This function is executed after the offset command is received and the DSP OFS (REL) key command is received before any offset information is entered. When this command is received the value calculated below is entered as the offset. This offset is in dB and is defined to be:

In ratio or difference mode with entry channel K:

If ratio or difference order is J to K then
OFFSET= OFFSET(K) - 10 * LOG(POWER(K)/POWER(J))

If ratio or difference order is K to J then
OFFSET= OFFSET(J) + 10 * LOG(POWER(K)/POWER(J))

In single channel K mode:

If entry channel is K then

```
        OFFSET= OFFSET(K) - 10 * LOG(POWER(K))
    If entry channel is J then
        OFFSET= 999.9
```

Where power is in mW and is the power that would be displayed if the system were in single channel watts mode, also where J can equal A or B and K can equal A or B. If the offset as calculated above results in an illegal offset entry, the number 999.9 will be displayed and the meter will generate an offset entry error if the ENTER command is received after this is put into the offset entry display.

OSC — The state of the reference oscillator changes from on to off or from off to on. When the oscillator is on, the LED next to the OSC key is on. Storage location 0 is updated by this command.

POWER ON-LCL — If the LCL key is held down while the power is turned on the meter enters the HP-IB address entry mode. In this mode an address can be entered from the front panel. This command is not available over the HP-IB.

PRESET — The Power Meter is put into a preset state. In the preset state parameters for channels A and B are set to the following conditions:

```
Cal Factor = 100.0%
Offset = 0.00 dB
Low Limit = 0.000 dB
High Limit = 0.000 dB
Auto Filter
Auto Range
```

The meter is set to the following conditions:

```
Display Sensor A
Reference Oscillator is OFF
Enter A Mode
Watts Mode
Limits checking is OFF
Rel Mode is OFF
Group execute trigger mode (GT2)
Meter is in free-run mode
```

The parameters not affected by preset are the zero and calibration information for each sensor and the storage registers, except that storage location 0 is updated by this command.

RECALL — This command has the same form as the STORE command except the information stored by STORE is recalled by

RECALL. When the RECALL command is received the meter waits for the user to enter a location in the range 0 to 19. When the location is entered the meter recalls the stored information, configures the meter to that information, and starts measuring power in the new mode. RECALL location 0 always contains the last state of the Power Meter. Recalling location 0 will return the meter to the state it was in before the last change was made. This command updates storage location 0.

REL — REL mode is enabled or disabled. The REL command toggles between REL mode enabled and REL mode disabled. When REL mode is enabled, the annunciator indicating REL mode is lit, the last power reading is saved as a reference, and readings are displayed in reference to it. The display units are either %, if linear (WATT) mode is enabled, or dB, if logarithmic mode is enabled. If REL mode was enabled before the REL key was pressed, the system returns to a nonreferenced power display and the REL display turned off. Storage location 0 is updated by this command.

SET A — The Power Meter is put into enter A mode. In this mode any front panel or bus functions that act on a channel will act on the A channel. Storage location 0 is updated by this command.

SET B — The Power Meter is put into enter B mode. In this mode any front panel or bus functions that act on a channel will act on the B channel. Storage location 0 is updated by this command.

SHIFT — Enables shifted functions of the A, B, B/A keys. The shift function is disabled when any other command is received by the Power Meter either from the front panel or over the bus. If a key is pressed which does not have a shifted function defined, the normal function of that key will be executed and the shift function will be aborted.

STORE — The Power Meter enters the store Power Meter state mode. The numeric entry mode becomes active and the user can enter a storage register location in the range 1 to 19 (location 0 is reserved). Refer to RECALL for more information. Front panel STORE entries accept 2 digits. If more than 2 digits are entered the displayed number shifts left and the new digit is used. If a zero is input as the first digit it is displayed, but any other digit input will take its place rather than be to the

right of it. When the storage location is entered by the receipt of the ENTER command, the display returns to its previous mode after storing the following information:

measurement mode (A, B, A-B...)
REL mode state (on/off)
reference oscillator state (on/off)
enter A or enter B state
current reference value (if in REL mode)
dBm WATT (log/lin) mode

And for each sensor:

cal factor
offset
range auto/mnl (range number if manual)
filter auto/mnl (filter number if manual)

ZERO — The Power Meter enters the auto zero routine and attempts to zero the selected power sensor. When the zero routine is completed (about 10 seconds) the new zero values are stored and the Power Meter is returned to measuring power.

If the meter, for some reason cannot be zeroed, a zeroing error will occur. Refer to error descriptions for more information on errors. Any command received during the zeroing process will abort the zeroing and execute the function of the command received. (If the ZERO command is received it will simply abort the zeroing process.)

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

The procedures in this section test the instrument's electrical performance using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in Section III under Basic Functional Checks.

NOTE

If the performance tests are to be considered valid, the following conditions must be met:

a. The Power Meter must have a 1 hour warm-up for all specifications.

b. The line voltage for all instruments must be 100, 120, 220, or 240 Vac +5%, -10%; and the line frequency must be 48 to 66 Hz. The Power Meter has the additional capability of operating on line frequencies of 360 to 440 Hz, but the line voltage is limited to a nominal 100 or 120 Vac.

c. The ambient temperature must be 0°C to 55°C.

4-2. EQUIPMENT REQUIRED

Equipment required for the performance tests is listed in Table 1-3, Recommended Test Equipment. Any equipment that satisfies the critical specifications given in the table may be substituted.

4-3. PERFORMANCE TEST RECORD

Results of the performance test may be tabulated in Table 4-1, Performance Test Record. The Performance Test Record lists all of the performance test specifications and the acceptable limits for each specification. If performance test results are recorded during an incoming inspection of the instrument, they can be used for comparison during periodic maintenance or troubleshooting procedures. The test results may also prove useful in verifying proper adjustments after repairs are made.

4-4. PERFORMANCE TESTS

The performance tests given in this section are suitable for incoming inspection, troubleshooting, or preventive maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify published instrument specifications. Perform the tests in the order given and record the data on the test card and/or in the data spaces provided at the end of each procedure.

4-5. CALIBRATION CYCLE

This instrument requires periodic verification of performance to ensure that it is operating within specified tolerances. The performance tests described in this section should be performed at least once each year; under conditions of heavy usage or severe operating environments, the tests should be more frequent. Adjustments that may be required are described in Section V, Adjustments.

4-6. ABBREVIATED PERFORMANCE TEST

Refer to Section III, Operation, for a Basic Functional Checks test.

4-7. TEST PROCEDURES

It is assumed that the person performing the following tests understands how to operate the specified test equipment. Equipment settings, other than those for the Power Meter, are stated in general terms. It is also assumed that the technician will select the power sensor, cables, adapters and probes required for test setups illustrated in this section.

PERFORMANCE TESTS

4-8. ZERO CARRYOVER TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
ACCURACY Zero set Digital sensability of zero	±0.5% full scale	Most sensitive range. Decrease percentage by factor of 10 for each higher range ±1 count.

Description After the Power Meter is initially zeroed, the change in the digital readout is monitored as the Power Meter is stepped through its ranges. This test also takes drift and noise into account, since drift, noise and zero carryover readings cannot be separated.

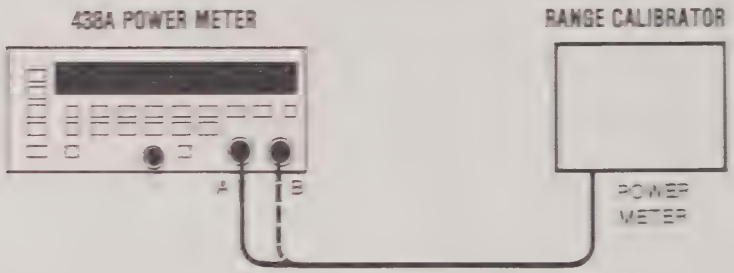


Figure 4-1. Zero Carryover Test Setup

Equipment

Range Calibrator	HP 11683A
Power Sensor Cable	HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-1.

2. Set the Power Meter controls as follows:

LINE	ON
PRESS	PRESET

3. Set the range calibrator switches as follows:

FUNCTION	STANDBY
LINE	ON

4. Press the Power Meter's ZERO switch and wait approximately 15 to 17 seconds for the display to reappear and stabilize. Verify that the reading is 0.00 ±0.06.

NOTE

The Power Meter is now zeroed on range 1 (most sensitive).

5. Press MNL RANGE, then 1, then ENTER.

PERFORMANCE TESTS

4-8. ZERO CARRYOVER TEST (cont'd)

Procedure (cont'd)

6. After the Power Meter reading has stabilized, verify that the indication is within the limits shown.

Power Meter Range	Results			
	Min	Actual		Max
		A	B	
1	−0.06 µW	_____	_____	0.06 µW
2	−0.1 µW	_____	_____	0.1 µW
3	−0.001 mW	_____	_____	0.001 mW
4	−0.01 mW	_____	_____	0.01 mW
5	−0.1 mW	_____	_____	0.1 mW

7. Repeat steps 5 and 6 by entering 2, then 3, then 4, and 5.

8. Repeat steps 2 through 7 for Channel B by pressing B in Step 2.

PERFORMANCE TESTS

4-9. INSTRUMENT ACCURACY TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
ACCURACY Instrumentation includes sensor linearity		
Single channel mode	±0.02 dB	Within same calibration range
	Plus ±0.02 dB	Outside calibration range
Dual channel mode (Ratio or difference)	Multiply single channel specifications by 2	

Description

After the Power Meter is initially calibrated on the 1 mW range, the readout is monitored as the range calibrator is switched to provide reference inputs corresponding to each of the Power Meter operating ranges.

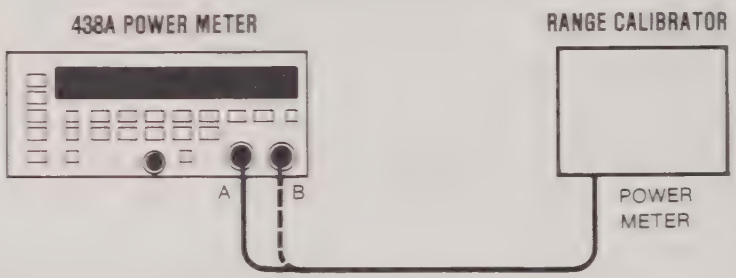


Figure 4-2. Instrument Accuracy Test Setup

Equipment

Range Calibrator ..... HP 11683A
Power Sensor Cable ..... HP 11730A

Procedure

1. Connect the equipment as shown in Figure 4-2.

2. Set the Power Meter controls as follows:

LINE ..... ON
SENSOR ..... A
PRESS ..... PRESET

3. Set the range calibrator switches as follows:

FUNCTION ..... STANDBY
POLARITY ..... NORMAL
RANGE ..... 1 mW
LINE ..... ON

PERFORMANCE TESTS

4-9. INSTRUMENT ACCURACY TEST (cont'd)

Procedure (cont'd)

4. Press the Power Meter ZERO key, and wait for the readout to reappear. Verify that the reading is 0.00 ± 0.06 μW

5. Set the range calibrator FUNCTION switch to CALIBRATE.

6. Press Power Meter CAL ADJ key, then press ± key to get minus (−) sign, then press 100 ENTER. The minus sign indicates use of an external reference source. If the minus sign is not used there will be a NO REF error on the display.

7. Verify that the Power Meter display reads 1.000 ±0.006 mW.

NOTE

The range calibrator output level is adjustable in 5 dB increments. Thus, the 3 μW, 30 μW, 300 μW, 3 mW, and 30 mW legends on the RANGE switch are approximations. The true values for these settings are 3.16, 31.6, and 316 μW, 3.16 mW and 31.6 mW.

8. *Set the range calibrator RANGE switch to the 10 μW* position, and then to the 100 μW, 10 mW and 100 mW positions. For each setting, verify that the Power Meter autoranges properly, and that the display is within the limits shown.

Range Calibrator Range	Results		
	Min	Actual	Max
10 μW	9.90 μW	_____	10.10 μW
100 μW	99.0μW	_____	101.0 μW
1 mW	0.995 mW	_____	1.005 mW
10 mW	9.90 mW	_____	10.10 mW
100 mW	99.0 mW	_____	101.0 mW

9. Press the Power Meter channel B key and repeat steps 4 through 6 to test channel B.

10. Set the Power Meter dBm/WATT switch to the dBm position and verify that the display changes to the dBm mode, and that the indication is within 20.00 ± 0.02 dBm. It is not necessary to check all ranges in both modes since the same circuitry is used to measure power and only a conversion is performed.

19.98 dBm _____ 20.02 dBm

11. Set the range calibrator RANGE switch to -10 dBm.

12. Verify that the Power Meter displays -10.00 ±0.02 dBm.

-9.98 dBm _____ -10.02 dBm

13. Press the Power Meter REL key and verify that the display indicates 0.00 ±0.01 dB.

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST

Specification

Electrical Characteristics	Performance Limits	Conditions
Power reference	1.00 mW	Internal 50 MHz oscillator factory set to ±0.7% traceable to National Bureau of Standards
Power Reference Accuracy	±1.2% ±0.9%	Worst case RSS for one year

Description

The power reference oscillator output is factory adjusted to 1 mW ±0.7%. To achieve this accuracy, Hewlett-Packard employs a special measurement system accurate to 0.5% (traceable to the National Bureau of Standards) and allows for a transfer error of ± 0.2% in making the adjustment. If an equivalent measurement system is employed for verification, the power reference oscillator output can be verified to 1 mW ±1.9% (±1.2% accuracy plus ±0.5% verification system error plus ±0.2% transfer error =1.9% maximum error). The power reference oscillator can be set to ±0.7% using the same equipment and following the adjustment procedure. To ensure maximum accuracy in verifying the power reference oscillator output, the following procedure provides step by step instructions for using specified Hewlett-Packard test instruments of known capability. If equivalent test instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the instruments.

NOTE

The Power Meter may be returned to the nearest Hewlett-Packard office to have the power reference oscillator checked and/or adjusted. Refer to Section II, Packaging.

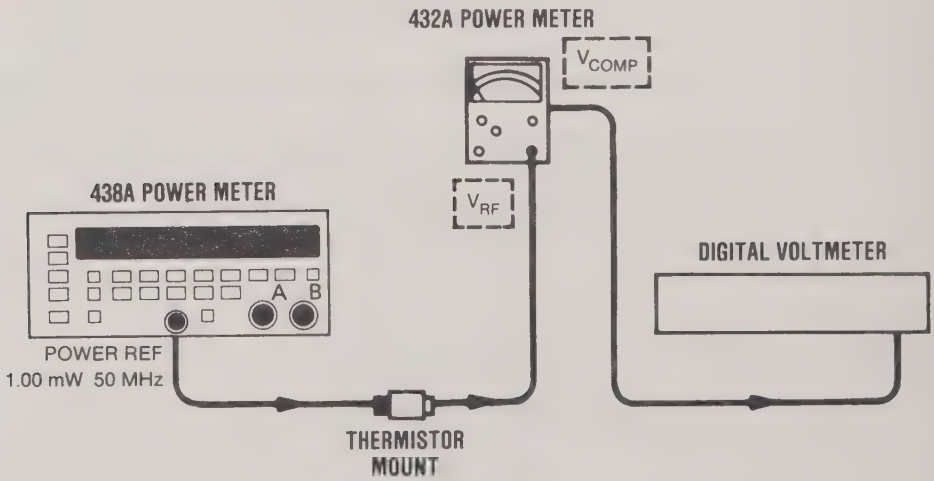


Figure 4-3. Power Reference Level Test Setup

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST (cont'd)

Equipment

Test Power Meter	HP 432A
Thermistor Mount	HP 478A-H75
Digital Voltmeter (DVM)	HP 3456A

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the Vrf connector on the rear panel of the test power meter, and pin 1 on the thermistor mount end of the test power meter interconnect cable.

2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

   R _____

3. Connect the test power meter to the Power Meter as shown in Figure 4-3.

4. Set the Power Meter LINE switch to ON and the OSC switch off (LED off). Then wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.

5. Set the test power meter Range switch to Coarse Zero and adjust the front panel Coarse Zero control to obtain a zero meter indication.

6. Fine Zero the test power meter on the most sensitive range, then set the test power meter Range switch to 1 mW.

NOTE

Ensure that DVM input leads are isolated from chassis ground when performing the next step.

7. Set up the DVM to measure microvolts and connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.

8. Observe the indicaion on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter Fine Zero switch and adjust the Coarse Zero control so that the DVM indicates 200 microvolts or less. Then release the Fine Zero switch and proceed to the next step.

9. Round off the DVM indication to the nearest microvolt and record this value as V_0.

   V_0 _____

10. Set the Power Meter OSC switch to ON (LED on) and record the indications observed on the DVM as V_1.

    V_1 _____

PERFORMANCE TESTS

4-10. POWER REFERENCE LEVEL TEST (cont'd)

Procedure (cont'd)

11. Disconnect the DVM negative input lead from the Vrf connector on the test power meter and reconnect it to test power meter chassis ground. Record the new indication observed on the DVM as Vcomp.

V_{comp} _____

12. Calculate the power reference oscillator output level (Prf) from the following formula:

$$Prf = \frac{2V_{comp}(V_1 - V_0) + V_0^2 - V_1^2}{4R\ (\text{Calibration Factor})}$$

Where:

Prf = power reference oscillator output level
V_{comp} = previously recorded value
V1 = previously recorded value
V0 = previously recorded value
R = previously recorded value

Calibration Factor = value for thermistor mount at 50 MHz (traceable to the National Bureau of Standards).

13. Verify that the Prf is within the following limits:

Min	Actual	Max
0.988 mW	_____	1.012 mW

Table 4-1. Performance Test Record

Hewlett-Packard Company
Model HP 438A
Power Meter

Tested by _____

Serial Number _____ Date _____

Para. No.	Test	Minimum	Results Actual	Maximum
4-8.	**ZERO CARRYOVER**			
	Power Meter Range			
	1	−0.06 μW	_____	10.06 μW
	2	−0.1μW	_____	0.1 μW
	3	−0.001 mW	_____	0.001 mW
	4	−0.01 mW	_____	0.01 mW
	5	−0.1 mW	_____	0.1 mW
4-9.	**INSTRUMENT**			
	Accuracy			
	Watt Mode			
	10 μW	9.90μW	_____	10.10 μW
	100 μW	99.0μW	_____	101.0 μW
	1 mW	0.995 mW	_____	1.005 mW
	10 mW	9.90 mW	_____	10.10 mW
	100 mW	99.0 mW	_____	101.0 mW
	dBm Mode			
	20 dBm	19.98 dBm	_____	20.02 dBm
4-10.	**POWER REFERENCE**			
	Prf	0.988 mW	_____	1.012 mW

SECTION V
ADJUSTMENTS

5-1. INTRODUCTION

This section contains adjustments and checks that ensure proper performance of the Power Meter. Adjustments are not required on any fixed periodic basis, and normally are performed only after a performance test has indicated that some parameters are out of specification. Performance tests should be completed after any repairs that may have altered the characteristics of the instrument. The test results will make it possible to determine whether or not adjustments are required. Allow 60 minutes for the Power Meter to warm up, and then remove the top and bottom covers, also loosen the screws holding the A3 CPU Assembly and A5 Main Amplifier Assembly for access to the test and adjustment points.

To determine which performance tests and adjustments to perform after a repair, refer to paragraph 5-6, Post-Repair Tests, Adjustments, and Checks.

5-2. SAFETY CONSIDERATIONS

This section contains a warning that must be followed for your protection and to avoid damage to the equipment being used.

WARNING

Adjustments described in this section are performed with power applied to the instrument and with protective covers removed. Maintenance should be performed only by trained personnel who are aware of the hazards involved. When the maintenance procedure can be performed without power, the power should be removed.

5-3. EQUIPMENT REQUIRED

Most of the adjustment procedures include a list of recommended test equipment, and the test equipment is also identified on the test setup diagrams. If substitutions must be made, the equipment used must meet the critical specification listed in Table 1-3 in Section I.

5-4. FACTORY SELECTED COMPONENTS

Factory selected components are identified on the schematics and parts lists by an asterisk(*) which follows the reference designator. The nominal value of the selected component is shown. Table 5-1 lists the reference designator, the service sheet where the component is shown, the value range, and the basis for selecting a particular value.

5-5. INTERRELATED ADJUSTMENTS

The −15V adjustment on the A9 Regulator Assembly should be the first item checked during any adjustment procedure. The −15V source and the +15V source are such that they are equal but opposite in sign. The +5V (D) digital is measured and adjusted second before the other adjustment procedures are started.

NOTE

Make adjustments only in the order specified

5-6. POST-REPAIR ADJUSTMENTS

Table 5-2 lists the adjustments related to repairs or replacement of any of the assemblies.

Table 5-1. Factory Selected Components

Reference Designator	Service Sheet	Range of Values	Basis of Selection
G1A1R2 G1A1VR2 combination	11	825Ω with 5.11V Zener or 1470Ω with 8.25V Zener	1. If the reference power is outside the range of 1.000±0.007 mW between 0°C and 55°C, and if the G1A1R2, G1A1VR2 combination is 825Ω 5.11V then change the G1A1R2, G1A1VR2 combination to 1470Ω 8.25V. However, if the G1A1R2, G1A1VR2 combination is already 1470Ω 8.25V, then a problem exists elsewhere.

Table 5-2. Post-Repair Adjustments, Tests, and Checks

Assembly Repaired	Related Adjustment or Performance Test	Reference Service Sheet
A1 Keyboard	None	1
A2 Display	None	5
A3 Central Processing Unit	5-7, 5-8, 5-9	1,2,3,4
A4 Input Amplifier	5-7, 5-8, 5-10, 5-11	6
A5 Main Amplifier	5-7, 5-8, 5-9	7,8
A8 Rectifier	4-10, 4-11, 4-12, 4-13, 5-7, 5-8	9
A9 Regulator	4-8, 4-9, 5-7, 5-8	9,10
G1 50 MHz Reference Oscillator	5-7, 5-8, 5-12, 5-13	11

ADJUSTMENTS

5-7. ±15 VOLT POWER SUPPLY ADJUSTMENT

Reference Service Sheet 10

Description The +15 volt supply is measured, then the −15 volt supply is measured and adjusted so that the supplies are equal in amplitude but of opposite sign.

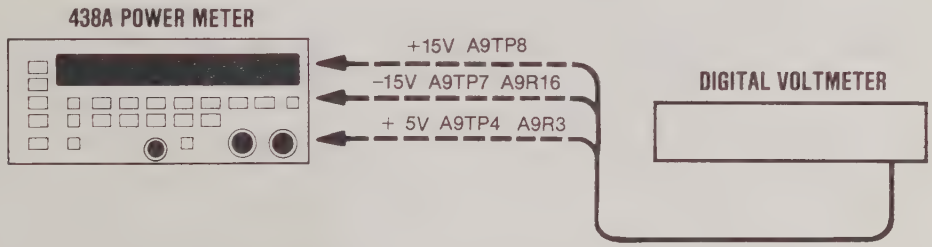


Figure 5-1. Power Supply Adjustments Setup

Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. Remove the top and bottom covers of the Power Meter. Loosen screws that secure the A3 CPU Assembly. Turn the instrument on and allow for the warm-up.

2. Connect the DVM between the +15V testpoint A9TP8 and chassis ground. Measure and record the value of the +15 volts. The voltage should be between 14.25 and 15.75 Vdc.

   +15V _____

3. Connect the DVM between the −15V testpoint A9TP7 and chassis ground. Adjust −15V, A9R16, until the DVM reading is within 0.05 Vdc of the numerical value from step 2. Ignore the difference in sign for this adjustment.

ADJUSTMENTS

5-8. +5 VOLT POWER SUPPLY ADJUSTMENT

Reference Service Sheet 9

Description The +5 volt supply is measured and adjusted.

Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. See Figure 5-1. Connect the DVM between the −5V testpoint A9TP4 and ground. Adjust +5V, A9R3 to 5.00 ± 0.05 volts as read on the DVM.

ADJUSTMENTS

5-9. ANALOG TO DIGITAL CONVERTER SLOPE ADJUSTMENT

Reference Service Sheet 8

Description The Analog to Digital Converter is adjusted for a central reading.

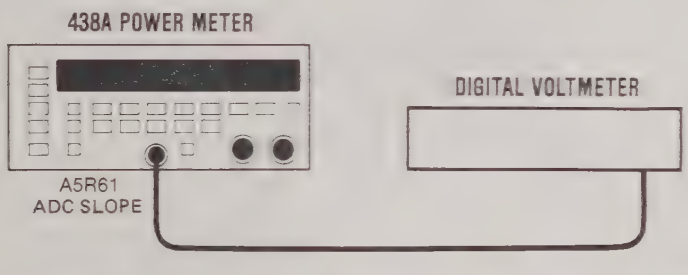


Figure 5-2. Analog to Digital Converter Slope Adjustment Setup

Equipment Digital Voltmeter (DVM) ..... HP 3456A

Procedure

1. Turn the Power Meter off. Place all 4 switches of A3S1 to the test position. This would be positions where the switches are all opposite to the normal operating position.

2. Turn the Power Meter on. The instrument should now display — — — — — . Connect the digital DVM between B-GND A5TP2 and +2.5V REF A5TP8 test-points on A5. Read the DVM.

   _____

3. Enter the reading to 5 digits (4 decimal places) into the Power Meter by entering the numbers into the keyboard, then pressing ENTER.

4. Adjust the ADC SLOPE, A5R61, so that the display reading is centered about zero. (The reading may be from +5.00 to -5.00, try to get as close to zero as possible.

5. Turn off the Power Meter. Return A3S1 to its original position.

ADJUSTMENTS

5-10. 220 Hz FREQUENCY ADJUSTMENT

Reference Service Sheet 6

Description The 220 Hz is adjusted for maximum Power Meter readout.

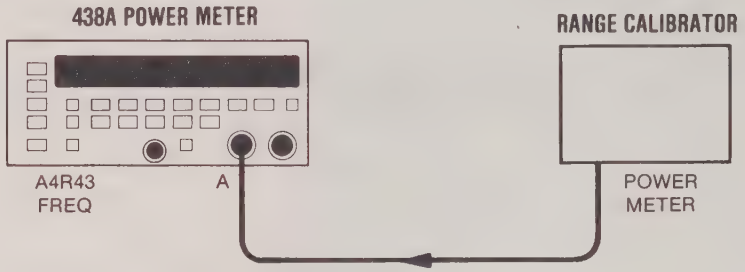


Figure 5-3. 220 Hz Frequency Adjustment Setup

Equipment Range Calibrator ..... HP 11683A

Procedure

1. Turn on both the Power Meter and the range calibrator. Set the range calibrator controls as follows:

   LINE ..... ON
   RANGE ..... 1 mW
   FUNCTION ..... STANDBY
   POLARITY ..... NORMAL

2. Connect the range calibrator output to channel A using the sensor cable. Press PRESET on the Power Meter then press ZERO, and allow time (approximately 15 to 17 seconds) for the Power Meter zeroing process.

3. Set the range calibrator function switch to calibrate.

4. On the Power Meter press CAL ADJ, (–), 100, then ENTER. This procedure allows the Power Meter to calibrate using an external reference, the range calibrator output.

5. Adjust 220 Hz, A4R43, for the maximum front panel reading.

ADJUSTMENTS

5-11. RANGES 4 and 5 SHAPER ADJUSTMENT, CHANNEL A AND B

Reference Service Sheet 6

Description Ranges 4 and 5 Shaper circuits are adjusted for proper gain.

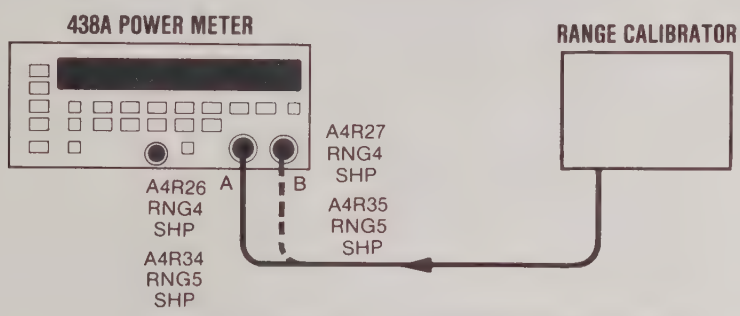


Figure 5-4. Ranges 4 and 5 Shaper Adjustment Setup

Equipment Range Calibrator ..... HP 11683A

Procedure

1. Connect range calibrator to channel A input connector.
2. Set the range calibrator controls as follows:

   LINE ..... ON
   RANGE ..... 1 mW
   FUNCTION ..... STANDBY
   POLARITY ..... NORMAL

3. Turn on the Power Meter, and press PRESET. After zeroing the Power Meter, set the range calibrator to calibrate, then press CAL ADJ, (-), 100, and ENTER on the Power Meter.
4. Set the range calibrator range to 10 mW.
5. Adjust RNG 4, A4R26, for a reading of 10.00 ±0.01 mW on the Power Meter display.
6. Set the range calibrator range to 100 mW.
7. Adjust RNG 5, A4R34, for a reading of 100.0 ±0.1 mW on the Power Meter display.
8. Repeat steps 5 through 7 to check that interaction between steps has not caused a shift in settings.
9. Repeat the procedure for channel B of the Power Meter by making connection to channel B from the range calibrator.
10. Repeat the above procedure, starting with step 3, except press B on the Power Meter. Adjust RNG 4 SHP, A4R27, and RNG 5 SHP, A4R35, as in steps 5 and 7 above.

ADJUSTMENTS

5-12. POWER REFERENCE OSCILLATOR FREQUENCY ADJUSTMENT

NOTE

Adjustment of the Power Reference Oscillator frequency may also affect the output level of the oscillator. Thus after the frequency is adjusted 50.0 ±0.5 MHz, the output level should be checked as described in Section IV. A procedure for adjusting the output to the specified level is provided in the next paragraph.

Reference Service Sheet 11

Description Variable inductor G1A1L1 is adjusted to set the power reference oscillator output frequency to 50.0 ±0.5 MHz.

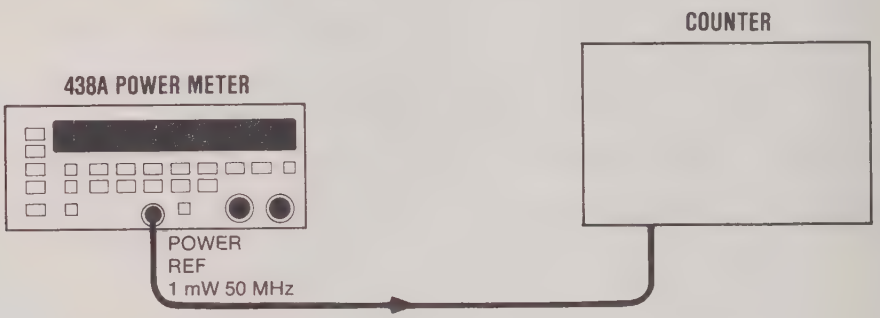


Figure 5-5. Power Reference Oscillator Frequency Adjustment Setup

Equipment Frequency Counter ..... HP 5328A Option 031

Procedure

1. Connect the equipment as shown in Figure 5-5 and set up the counter to measure frequency.
2. Set the Power Meter LINE switch to ON (in) and the POWER REF OSC switch to OFF (LED off).
3. Set the Power Meter POWER REF OSC switch to ON (LED on) and observe the indication on the counter. If it is 50.0 ± 0.5 MHz, no adjustment of the power reference oscillator frequency is necessary. If it is not within these limits, adjust the power reference oscillator frequency as described in steps 4 and 5.
4. Remove the Power Meter top cover, and loosen screws holding the A3 CPU Assembly. Swing out the assembly and the screwdriver adjustment is accessible through a hole in the deck.
5. Adjust G1A1L1 to obtain a 50.00 ± 0.5 MHz indication on the counter.

ADJUSTMENTS

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT

Reference Service Sheet 11

Description The power reference oscillator is factory-adjusted to 1.0 mW ± 0.7% using a special measurement system accurate to 0.5% (traceable to the National Bureau of Standards) and allowing for a 0.2% transfer error. To ensure maximum accuracy in readjusting the power reference oscillator, the following procedure provides step-by-step instructions for using specified Hewlett-Packard instruments of known capability. If equivalent instruments are used, signal acquisition criteria may vary and reference should be made to the manufacturer's guidelines for operating the equipment.

NOTE

The Power Meter may be returned to the nearest HP office to have the power reference oscillator checked and/or adjusted. Refer to Section II PACKAGING

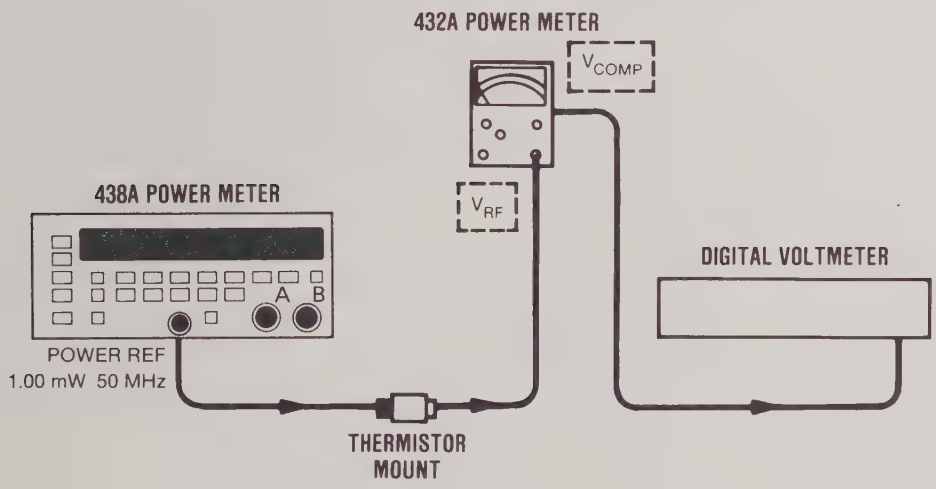


Figure 5-6. Power Reference Oscillator Level Adjustment Setup

Equipment

Test Power Meter	HP 432A
Thermistor Mount	HP 478A-H75
Digital Voltmeter (DVM)	HP 3456A

Procedure

1. Set up the DVM to measure resistance and connect the DVM between the Vrf connector on the rear panel of the test power meter and pin 1 on the thermistor mount end of the test power meter interconnect cable.

ADJUSTMENTS

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

Procedure (cont'd)

2. Round off the DVM indication to two decimal places and record this value as the internal bridge resistance (R) of the test power meter (approximately 200 ohms).

   R (Internal Bridge Resistance) _____

3. Connect the test power meter to the Power Meter as shown in Figure 5-5.

4. Set the Power Meter LINE switch to ON and the POWER REF OSC switch off. Wait thirty minutes for the test power meter thermistor mount to stabilize before proceeding to the next step.

5. Set the test power meter range switch to coarse zero and adjust the front panel coarse zero control to obtain a zero meter indication.

6. Fine zero the test power meter on the most sensitive range, then set the test power meter range switch to 1 mW.

NOTE

Ensure that the DVM input leads are isolated from chassis ground when performing the next step.

7. Set up the DVM to measure microvolts and connect the positive and negative input leads, respectively, to the Vcomp and Vrf connectors on the rear panel of the test power meter.

8. Observe the indication on the DVM. If less than 400 microvolts, proceed to the next step. If 400 microvolts or greater, press and hold the test power meter fine zero switch and adjust the coarse zero control so that the DVM indicates 200 microvolts or less. Then release the fine zero switch and proceed to the next step.

9. Round off the DVM indication to the nearest microvolt and record this value as V_0.

   V_0 _____

10. Disconnect the DVM negative input lead from the Vrf connector on the test power meter and reconnect it to chassis ground.

11. Set the Power Meter POWER REF OSC on and record the indication observed on the DVM as V_{comp}.

    V_{comp} _____

12. Disconnect the DVM negative input lead from chassis ground and reconnect it to the Vrf connector on the rear panel of the test power meter. The DVM is now set up to measure V_1 which represents the power reference oscillator output level.

13. Calculate the value of V_1 equal to 1 mW from the following equation:

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

$$V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - (10^{-3})(4R)(\text{EFFECTIVE EFFICIENCY})}$$

where:

V_0 = previously recorded value

V_{COMP} = previously recorded value

10^{-3} = 1 milliwatt

R = previously recorded value

EFFECTIVE EFFICIENCY = value for thermistor mount at 50 MHz (traceable to the National Bureau of Standards).

14. Remove the Power Meter top cover and adjust LEVEL ADJUST potentiometer G1A1R4 so that the DVM indicates the calculated value of V_1.

TYPICAL CALCULATIONS:

1. ACCURACY:

DVM Measurements:	(V_{COMP})	±0.018%
	$(V_1 - V_0)$	±0.023%
	(R)	±0.03%
Math Assumptions:		±0.01%
EFFECTIVE EFFICIENCY CAL (NBS):		±0.5%
MISMATCH UNCERTAINTY: (Source & Mount SWR ≤1.05)		±0.1%
		≤ ±0.7%

2. MATH ASSUMPTIONS:

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Assume: $V_0^2 - V_1^2 = (V_1 - V_0)^2$

$-(V_1 - V_0)^2 = -V_1^2 + 2V_1 - V_0^2$

Want: $V_0^2 - V_1^2$

$\therefore$ error = $(V_1^2 + 2V_1 V_0 - V_0^2) - (V_0^2 - V_1^2) = -2V_0^2 + 2V_1 V_0 = 2V_0(V_1 - V_0)$

if $2V_0(V_1 - V_0) << 2V_{COMP}(V_1 - V_0)$ i.e., $V_0 << V_{COMP}$, error is negligible.

$V_{COMP} \sim 4$ volts. If $V_0 < 400\ \mu V$, error is $< 0.01\%$.

(typically V_0 can be set to $< 50\ \mu V$).

5-13. POWER REFERENCE OSCILLATOR LEVEL ADJUSTMENT (cont'd)

TYPICAL CALCULATIONS (cont'd)

3. Derivation of Formula for $V_1 - V_0$

$$P_{RF} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Desired $P_{RF} = 1\ \text{mW} = 10^{-3}$

$$\therefore 10^{-3} = \frac{2V_{COMP}(V_1 - V_0) + V_0^2 - V_1^2}{(4R)(\text{EFFECTIVE EFFICIENCY})}$$

Let (4R) (EFFECTIVE EFFICIENCY) $(10^{-3}) = K$

Substitute $-(V_1 - V_0)^2$ for $V_0^2 - V_1^2$ (see Math Assumptions under Accuracy)

Then $0 = (V_1 - V_0)^2 - 2V_{COMP}(V_1 - V_0) + K$

or $V_1 - V_0 = V_{COMP} - \sqrt{(V_{COMP})^2 - K}$

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

This section contains information for ordering parts. Table 6-1 lists part numbers for restored assemblies. Table 6-2 lists abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-4 contains the names and addresses that correspond to the manufacturer's code numbers.

6-2. ABBREVIATIONS

Table 6-2 lists abbreviations used in the parts list, schematics, and throughout the manual. In some cases, two forms of the abbreviation are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts list are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper case letters.

6-3. REPLACEABLE PARTS LIST

Table 6-3 is the list of replaceable parts and is organized as follows:

a. Electrical assemblies and their components in alphanumeric order by reference designation.

b. Chassis-mounted parts in alphanumeric order by reference designation.

c. Mechanical parts.

The information given for each part consists of the following:

a. The Hewlett-Packard part number.

b. Part number check digit (CD).

c. Total quantity (Qty) used in the instrument.

d. Part description.

e. Five-digit code that represents a typical manufacturer.

f. Manufacturers part number.

NOTE

The total quantity for each part is given only once, that is, at the first occurrence of the part number in the list. The total quantities for optional assemblies are totalled by assembly and not integrated into the standard list.

6-4. FACTORY SELECTED PARTS (*)

Parts marked with an asterisk (*) are factory selected parts. The value listed in the parts list is the nominal value. Refer to Sections V and VIII of this manual for information on determining what value to use for replacement.

6-5. PARTS LIST BACKDATING (†)

Parts marked with a dagger (†) are different in Power Meters with serial number prefixes lower than the one that this manual applies to directly.

6-6. PARTS LIST UPDATING (Change Sheet)

Production changes to Power Meters made after the publication date of this manual are accompanied by a change in the serial number prefix. Changes to the parts list are recorded by serial number prefix on a MANUAL CHANGES supplement. Also, parts list errors are noted in the ERRATA portion of the MANUAL CHANGES supplement.

6-7. ILLUSTRATED PARTS BREAKDOWN

Most mechanical parts are identified in Figures 6-1 through 6-4. These figures are located at the end of the replaceable parts table.

6-8. ORDERING INFORMATION

To order a part listed in the replaceable parts table, include the Hewlett-Packard part number (with the check digit), and the quantity required. Address the order to the nearest Hewlett-Packard office. The check digit will ensure accurate and timely processing of your order.

To order a part that is not listed in the replaceable parts table, include the instrument model number,

ORDERING INFORMATION (cont'd)

instrument serial number, description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

NOTE

Within the USA, it is better to order directly from the HP Parts Center in Mountain View, California. Ask your nearest HP office for information and forms for the "Direct Mail Order System".

6-9. RECOMMENDED SPARES LIST

Stocking spare parts for an instrument is often done to ensure quick return to service after a malfunction occurs. Hewlett-Packard prepares a "Recommended Spares" list for this instrument. The contents of the list are based on failure reports and repair data. Quantities given are for one year of parts support. A complimentary copy of the "Recommended Spares" list may be requested from your nearest Hewlett-Packard office.

When stocking parts to support more than one Power Meter or to support a variety of Hewlett-Packard instruments, it may be more economical to work from one consolidated list rather than simply adding together stocking quantities from the individual instrument lists. Hewlett-Packard will prepare consolidated "Recommended Spares" lists for any number or combination of instruments. Contact your nearest Hewlett-Packard office for details.

6-10. RESTORED ASSEMBLIES

Table 6-1 lists assemblies within the instrument that may be replaced on an exchange basis, thus affording a considerable cost saving. Exchange, factory-repaired and tested assemblies are available only on a trade-in basis; therefore, the defective assemblies must be returned for credit. For this reason, assemblies required for spare parts stock must be ordered by the new assembly part number.

Table 6-1. Part Numbers for Restored Assemblies

Reference Designation	Description	Part Number[1]	
		Restored Assembly	New Assembly
A3	Central Processing Unit Assembly	00438-69003	00438-60003
A5	Main Amplifier Assembly	00438-69005	00438-60005

[1] When ordering extra assemblies for spare parts stock, use new assembly part number only. Restored orders require return of the defective part.

Table 6-2. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A . . . . . assembly
AT . . attenuator; isolator; termination
B . . . . . fan; motor
BT . . . . . battery
C . . . . . capacitor
CP . . . . . coupler
CR . . . . . diode; diode thyristor; varactor
DC . . . directional coupler
DL . . . . . delay line
DS . . . . . annunciator; signaling device (audible or visual); lamp; LED
E . . . . . miscellaneous electrical part
F . . . . . fuse
FL . . . . . filter
H . . . . . hardware
HY . . . . . circulator
J . . . electrical connector (stationary portion); jack
K . . . . . relay
L . . . . . coil; inductor
M . . . . . meter
MP . . . . . miscellaneous mechanical part
P . . . electrical connector (movable portion); plug
Q . . . . . transistor: SCR; triode thyristor
R . . . . . resistor
RT . . . . . thermistor
S . . . . . switch
T . . . . . transformer
TB . . . . . terminal board
TC . . . . . thermocouple
TP . . . . . test point
U . . . . . integrated circuit; microcircuit
V . . . . . electron tube
VR . . . . voltage regulator; breakdown diode
W . . . . cable; transmission path; wire
X . . . . . socket
Y . . . . crystal unit (piezoelectric or quartz)
Z . . . . tuned cavity; tuned circuit

ABBREVIATIONS

A . . . . . ampere
ac . . . . alternating current
ACCESS . . . . . accessory
ADJ . . . . . adjustment
A/D . . . . analog-to-digital
AF . . . . . audio frequency
AFC . . . . . automatic frequency control
AGC . . . . . automatic gain control
AL . . . . . aluminum
ALC . . . . . automatic level control
AM . . . amplitude modulation
AMPL . . . . . amplifier
APC . . . . automatic phase control
ASSY . . . . . assembly
AUX . . . . . auxiliary
avg . . . . . average
AWG . . . . American wire gauge
BAL . . . . . balance
BCD . . . . . binary coded decimal
BD . . . . . board
BE CU . . . . . beryllium copper
BFO . . . . . beat frequency oscillator
BH . . . . . binder head
BKDN . . . . . breakdown
BP . . . . . bandpass
BPF . . . . . bandpass filter
BRS . . . . . brass
BWO . . . . . backward-wave oscillator
CAL . . . . . calibrate
ccw . . counter-clockwise
CER . . . . . ceramic
CHAN . . . . . channel
cm . . . . . centimeter
CMO . . cabinet mount only
COAX . . . . . coaxial
COEF . . . . . coefficient
COM . . . . . common
COMP . . . . . composition
COMPL . . . . . complete
CONN . . . . . connector
CP . . . . . cadmium plate
CRT . . . cathode-ray tube
CTL . . . . complementary transistor logic
CW . . . . . continuous wave
cw . . . . . clockwise
cm . . . . . centimeter
D/A . . . . digital-to-analog
dB . . . . . decibel
dBm . . . . decibel referred to 1 mW
dc . . . . . direct current
deg . . degree (temperature interval or difference)
° . . . . . degree (plane angle)
°C . . . . . degree Celsius (centigrade)
°F . . . . degree Fahrenheit
°K . . . . . degree Kelvin
DEPC . . deposited carbon
DET . . . . . detector
diam . . . . . diameter
DIA . . . diameter (used in parts list)
DIFF AMPL . . differential amplifier
div . . . . . division
DPDT . . . . . double-pole, double-throw
DR . . . . . drive
DSB . . . . double sideband
DTL . . . . diode transistor logic
DVM . . . digital voltmeter
ECL . . . . emitter coupled logic
EMF . . electromotive force
EDP . . . . . electronic data processing
ELECT . . . . . electrolytic
ENCAP . . . . encapsulated
EXT . . . . . external
F . . . . . farad
FET . . . . . field-effect transistor
F/F . . . . . flip-flop
FH . . . . . flat head
FIL H . . . . . fillister head
FM . . frequency modulation
FP . . . . . front panel
FREQ . . . . . frequency
FXD . . . . . fixed
g . . . . . gram
GE . . . . . germanium
GHz . . . . . gigahertz
GL . . . . . glass
GRD . . . . . ground(ed)
H . . . . . henry
h . . . . . hour
HET . . . . . heterodyne
HEX . . . . . hexagonal
HD . . . . . head
HDW . . . . . hardware
HF . . . . . high frequency
HG . . . . . mercury
HI . . . . . high
HP . . . . . Hewlett-Packard
HPF . . . . . high pass filter
HR . . . . . hour (used in parts list)
HV . . . . . high voltage
Hz . . . . . Hertz
IC . . . . integrated circuit
ID . . . . . inside diameter
IF . . . . . intermediate frequency
IMPG . . . . . impregnated
in . . . . . inch
INCD . . . . . incandescent
INCL . . . . . include(s)
INP . . . . . input
INS . . . . . insulation
INT . . . . . internal
kg . . . . . kilogram
kHz . . . . . kilohertz
kΩ . . . . . kilohm
kV . . . . . kilovolt
lb . . . . . pound
LC . . . . . inductance-capacitance
LED . . light-emitting diode
LF . . . . . low frequency
LG . . . . . long
LH . . . . . left hand
LIM . . . . . limit
LIN . . . linear taper (used in parts list)
lin . . . . . linear
LK WASH . . . lock washer
LO . . . low; local oscillator
LOG . . . . logarithmic taper (used in parts list)
log . . . . . logrithm(ic)
LPF . . . . . low pass filter
LV . . . . . low voltage
m . . . . . meter (distance)
mA . . . . . milliampere
MAX . . . . . maximum
MΩ . . . . . megohm
MEG . . . . meg (10^6) (used in parts list)
MET FLM . . . . metal film
MET OX . . metallic oxide
MF . . . medium frequency; microfarad (used in parts list)
MFR . . . . . manufacturer
mg . . . . . milligram
MHz . . . . . megahertz
mH . . . . . millihenry
mho . . . . . mho
MIN . . . . . minimum
min . . . . . minute (time)
. . .' . . . . . minute (plane angle)
MINAT . . . . . miniature
mm . . . . . millimeter

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-2. Reference Designations and Abbreviations (2 of 2)

MOD . . . . . modulator
MOM . . . . . momentary
MOS . . . . . metal-oxide semiconductor
ms . . . . . millisecond
MTG . . . . . mounting
MTR . . . meter (indicating device)
mV . . . . . millivolt
mVac . . . . . millivolt, ac
mVdc . . . . . millivolt, dc
mVpk . . . . millivolt, peak
mVp-p . . . millivolt, peak-to-peak
mVrms . . . . millivolt, rms
mW . . . . . milliwatt
MUX . . . . . multiplex
MY . . . . . mylar
μA . . . . . microampere
μF . . . . . microfarad
μH . . . . . microhenry
μmho . . . . . micromho
μs . . . . . microsecond
μV . . . . . microvolt
μVac . . . . . microvolt, ac
μVdc . . . . . microvolt, dc
μVpk . . . microvolt, peak
μVp-p . . . microvolt, peak-to-peak
μVrms . . . . microvolt, rms
μW . . . . . microwatt
nA . . . . . nanoampere
NC . . . . . no connection
N/C . . . . normally closed
NE . . . . . neon
NEG . . . . . negative
nF . . . . . nanofarad
NI PL . . . . . nickel plate
N/O . . . . . normally open
NOM . . . . . nominal
NORM . . . . . normal
NPN . . . negative-positive-negative
NPO . . . . negative-positive zero (zero temperature coefficient)
NRFR . . not recommended for field replacement
NSR . . . . . not separately replaceable
ns . . . . . nanosecond
nW . . . . . nanowatt
OBD . . . order by description
OD . . . . . outside diameter
OH . . . . . oval head
OP AMPL . . . operational amplifier
OPT . . . . . option
OSC . . . . . oscillator
OX . . . . . oxide
oz . . . . . ounce
Ω . . . . . ohm
P . . . . peak (used in parts list)
PAM . . . . pulse-amplitude modulation
PC . . . . . printed circuit
PCM . . pulse-code modulation; pulse-count modulation
PDM . . . . . pulse-duration modulation
pF . . . . . picofarad
PH BRZ phosphor bronze
PHL . . . . . Phillips
PIN . . . positive-intrinsic-negative
PIV . . . . . peak inverse voltage
pk . . . . . peak
PL . . . . . phase lock
PLO . . . . . phase lock oscillator
PM . . . . phase modulation
PNP . . . positive-negative-positive
P/O . . . . . part of
POLY . . . . . polystyrene
PORC . . . . . porcelain
POS . . positive; position(s) (used in parts list)
POSN . . . . . position
POT . . . . . potentiometer
p-p . . . . . peak-to-peak
PP . . . peak-to-peak (used in parts list)
PPM . . . . . pulse-position modulation
PREAMPL . . . preamplifier
PRF . . . . pulse-repetition frequency
PRR . . . . pulse repetition rate
ps . . . . . picosecond
PT . . . . . point
PTM . . . . . pulse-time modulation
PWM . . . . . pulse-width modulation
PWV . . . . . peak working voltage
RC . . . . . resistance-capacitance
RECT . . . . . rectifier
REF . . . . . reference
REG . . . . . regulated
REPL . . . . . replaceable
RF . . . . . radio frequency
RFI . . . . radio frequency interference
RH . . . . round head; right hand
RLC . . . . . resistance-inductance-capacitance
RMO . . . rack mount only
rms . . . . root-mean-square
RND . . . . . round
ROM . . read-only memory
R&P . . . . . rack and panel
RWV . . . reverse working voltage
S . . . scattering parameter
s . . . . . second (time)
. . . " . second (plane angle)
S-B . . . . . slow-blow (fuse) (used in parts list)
SCR . . . silicon controlled rectifier; screw
SE . . . . . selenium
SECT . . . . . sections
SEMICON . . . . . semiconductor
SHF . . . . . superhigh frequency
SI . . . . . silicon
SIL . . . . . silver
SL . . . . . slide
SNR . . signal-to-noise ratio
SPDT . . . . . single-pole, double-throw
SPG . . . . . spring
SR . . . . . split ring
SPST . . . . . single-pole, single-throw
SSB . . . . . single sideband
SST . . . . . stainless steel
STL . . . . . steel
SQ . . . . . square
SWR . . standing-wave ratio
SYNC . . . . . synchronize
T . . timed (slow-blow fuse)
TA . . . . . tantalum
TC . . . . . temperature compensating
TD . . . . . time delay
TERM . . . . . terminal
TFT . . thin-film transistor
TGL . . . . . toggle
THD . . . . . thread
THRU . . . . . through
TI . . . . . titanium
TOL . . . . . tolerance
TRIM . . . . . trimmer
TSTR . . . . . transistor
TTL . . transistor-transistor logic
TV . . . . . television
TVI television interference
TWT . . traveling wave tube
U . . . . . micro (10^{-6}) (used in parts list)
UF . . . microfarad (used in parts list)
UHF . . ultrahigh frequency
UNREG . . . . unregulated
V . . . . . volt
VA . . . . . voltampere
Vac . . . . . volts, ac
VAR . . . . . variable
VCO . . . voltage-controlled oscillator
Vdc . . . . . volts, dc
VDCW . . volts, dc, working (used in parts list)
V(F) . . . . . volts, filtered
VFO . . variable-frequency oscillator
VHF . . . . . very-high frequency
Vpk . . . . . volts, peak
Vp-p . . volts, peak-to-peak
Vrms . . . . . volts, rms
VSWR . . . voltage standing wave ratio
VTO . . . . . voltage-tuned oscillator
VTVM . . . . vacuum-tube voltmeter
V(X) . . . . . volts, switched
W . . . . . watt
W/ . . . . . with
WIV . . . . working inverse voltage
WW . . . . . wirewound
W/O . . . . . without
YIG . . yttrium-iron-garnet
Z_o . . . . . characteristic impedance

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

Abbreviation	Prefix	Multiple
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
da	deka	10
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}
f	femto	10^{-15}
a	atto	10^{-18}

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	00438-60001	1	1	KEYBOARD ASSEMBLY	28480	00438-60001
A1J1	1200-0607	0	2	SOCKET-IC 16-CONT DIP DIP SLDR	28480	1200-0607
A1MP1	5041-2839	0	1	KEY CAP A	28480	5041-2839
A1MP2	5041-2840	3	1	KEY CAP B	28480	5041-2840
A1MP3	5041-2842	5	1	KEY CAP B/A	28480	5041-2842
A1MP4	5041-0319	5	2	KEY CAP 1/4 (BLANK)	28480	5041-0319
A1MP5	5041-2841	4	1	KEY CAP ZERO	28480	5041-2841
A1MP6	5041-2850	5	1	KEY CAP CAL ADJ	28480	5041-2850
A1MP7	5041-2851	6	1	KEY CAP CAL FACTOR	28480	5041-2851
A1MP8	5041-2854	9	1	KEY CAP OFFSET	28480	5041-2854
A1MP9	5041-2844	7	1	KEY CAP STORE	28480	5041-2844
A1MP10	5041-2849	2	1	KEY CAP REL	28480	5041-2849
A1MP11	5041-2848	1	1	KEY CAP DBM WATT	28480	5041-2848
A1MP12	5041-2886	7	1	KEY CAP LCL	28480	5041-2886
A1MP13	5041-2838	9	1	KEY CAP SHIFT	28480	5041-2838
A1MP14	5041-0319	5		KEY CAP 1/4 (BLANK)	28480	5041-0319
A1MP15	5041-2846	9	1	KEY CAP AUTO RANGE	28480	5041-2846
A1MP16	5041-2852	7	1	KEY CAP MAN RANGE	28480	5041-2852
A1MP17	5041-2847	6	1	KEY CAP AUTO FILTER	28480	5041-2847
A1MP18	5041-2853	8	1	KEY CAP MAN FILTER	28480	5041-2853
A1MP19	5041-2845	8	1	KEY CAP RECALL	28480	5041-2845
A1MP20	5041-2855	0	1	KEY CAP PRE SET	28480	5041-2855
A1MP21	5041-2843	6	1	KEY CAP OSC	28480	5041-2843
A1S1-A1S21	5060-9436	7	21	PUSHBUTTON SWITCH P.C. SWITCH	28480	5060-9436
A2	00438-60002	2	1	DISPLAY ASSEMBLY	28480	00438-60002
A2DS1	1990-0693	7	9	DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS2	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS3	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS4	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS5	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS6	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS7	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS8	1990-0693	7		DISPLAY-NUM-SEG 1-CHAR .3-H	28480	1DS1-3533
A2DS9	1990-0759	6	5	LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS10	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS11	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS12	1990-0587	8	2	DISPLAY-NUM-SEG 5-CHAR .11-H	28480	5082-7415
A2DS13	1990-0587	8		DISPLAY-NUM-SEG 5-CHAR .11-H	28480	5082-7415
A2DS14	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS15	1990-0759	6		LED-LIGHT BAR MODULE LUM-INT=3MCD	28480	HLMP-2620
A2DS16	1990-0665	3	1	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665
A2J1	1251-5720	5	1	CONNECTOR 34-PIN M POST TYPE	28480	1251-5720
A2MP1	0380-0059	5	1	SPACER-RVT-ON .25-IN-LG .152-IN-ID	00000	ORDER BY DESCRIPTION
A2MP2	00438-80006	8	1	LABEL-INFO	28480	00438-80006
A2XA1	1200-1055	4	14	SOCKET-IC 14 PIN	28480	1200-1055
A2XA2	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA3	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA4	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA5	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA6	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA7	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA8	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA9	1200-1056	5	5	SOCKET-IC 16 PIN	28480	1200-1056
A2XA10	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A2XA11	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A2XA12	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA13	1200-1055	4		SOCKET-IC 14 PIN	28480	1200-1055
A2XA14	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056
A2XA15	1200-1056	5		SOCKET-IC 16 PIN	28480	1200-1056

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3	00438-60003	3	1	CENTRAL PROCESSING UNIT ASSEMBLY	28480	00438-60003
A3BT1	1420-0314	2	1	BATTERY 3V 0.14A-HR LITHIUM POLYCARBON	28480	1420-0314
A3C1	0180-2815	1	1	CAPACITOR-FXD 100UF+-20% 10VDC TA	28480	0180-2815
A3C2	0180-2620	6	2	CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A3C3	0160-4554	7	49	CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C5	0180-1745	4	1	CAPACITOR-FXD 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A3C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C7	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C8	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C9	0160-0574	3	1	CAPACITOR-FXD .022UF +-20% 100VDC CER	28480	0160-0574
A3C10	0180-2617	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	25088	D6R8GS1B35K
A3C11	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C12	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C13	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C14	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C15	0160-3455	5	1	CAPACITOR-FXD 470PF +-10% 1KVDC CER	28480	0160-3455
A3C16	0180-0374	3	3	CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A3C17	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C18	0180-2620	6		CAPACITOR-FXD 2.2UF+-10% 50VDC TA	25088	D2R2GS1B50K
A3C19	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C20	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C21	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C22	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C23	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C24				NOT ASSIGNED		
A3C25	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C26	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C27	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C28	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C29	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C30	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C31	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C32	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C33	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C34	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C35	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C36	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C37	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C38	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C39	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C40	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C41	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C42	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C43	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3C44	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A3CR1	1901-0376	6	1	DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A3CR2	1901-1085	6	1	DIODE-SM SIG SCHOTTKY	28480	1901-1085
A3CR3	1901-0539	3	1	DIODE-SM SIG SCHOTTKY	28480	1901-0539
A3CR4				NOT ASSIGNED		
A3CR5				NOT ASSIGNED		
A3CR6	1906-0275	4	3	DIODE ARRAY	28480	1906-0275
A3CR7	1906-0275	4		DIODE ARRAY	28480	1906-0275
A3CR8	1906-0275	4		DIODE ARRAY	28480	1906-0275
A3DS1	1990-0933	8	2	LED-LAMP RED	28480	1990-0933
A3DS2	1990-0933	8		LED-LAMP RED	28480	1990-0933
A3J1	1251-5615	7	1	CONNECTOR 34-PIN M POST TYPE	28480	1251-5615
A3J2	1251-5286	8	2	CONNECTOR 4-PIN M POST TYPE	28480	1251-5286
A3J3	1251-4634	8	2	CONNECTOR 20-PIN M POST TYPE	28480	1251-4634
A3J4	1200-0607	0		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A3J5	1251-4833	9	2	CONNECTOR 34-PIN M POST TYPE	28480	1251-4833
A3J6	1251-4700	9	2	CONNECTOR 3-PIN M POST TYPE	28480	1251-4700
A3MP1	1400-1210	7	1	HOLDER-BAT 1-WD	28480	1400-1210
A3MP2	1200-0638	7	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0638
A3MP3	1200-0654	7	1	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A3MP4	0340-0944	3	1	INSULATOR-IC NYLON BLACK	28480	0340-0944
A3MP5	1200-0567	1	2	SOCKET-IC 28-CONT DIP DIP-SLDR	28480	1200-0567
A3MP6	00438-20029	9	5	HINGE RIVETED	28480	00438-20029
A3MP7	0403-0179	0	3	BUMPER FOOT-ADH MTG	28480	0403-0179
A3MP8	3050-0300	3	1	WASHER-FL NM NO. 4 .125-IN-ID .25-IN-OD	28480	3050-0300
A3MP9	3050-0892	8	1	WASHER-FL MTLC 3.5 MM 3.8-MM-ID	28480	3050-0892
A3MP10	0515-0506	4	1	SCREW-MACHINE ASSEMPLY M3.5 X 0.6 6MM-LG	00000	ORDER BY DESCRIPTION
A3MP11	0361-0009	5	4	RIVET-SEMITUB OVH .123 DIA .18GLG	00000	ORDER BY DESCRIPTION
A3MP12	00438-60034	0	2	CABLE ASSEMBLY MICRO	28480	00438-60034

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3Q1-						
A3Q19	1853-0281	9	19	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A3Q20	1854-0477	7	1	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A3R1	1810-0280	8	5	NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R2	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R3	0698-7283	4	1	RESISTOR 90.9K 1% .05W F TC=0+-100	24546	C3-1/8-T0-9092-F
A3R4	0698-7268	5	5	RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R5	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R6	0698-7212	9	4	RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R7	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R8	0698-7236	7	3	RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R9	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A3R10	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R11	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R12	0698-7268	5		RESISTOR 21.5K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2152-F
A3R13	0698-7269	6	1	RESISTOR 23.7K 1% .05W F TC=0+-100	24546	C3-1/8-T0-2372-F
A3R14	0698-3460	1	1	RESISTOR 422K 1% .125W F TC=0+-100	28480	0698-3460
A3R15	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R16	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R17	0698-7220	9	7	RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R18	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R19	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R20	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R21	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R22	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R23	0698-7253	8	1	RESISTOR 5.11K 1% .05W F TC=0+-100	24546	C3-1/8-T0-5111-F
A3R24	0757-0317	7	2	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A3R25	0698-7260	7	2	RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R26	0698-7260	7		RESISTOR 10K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1002-F
A3R27	0698-7236	7		RESISTOR 1K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1001-F
A3R28	0698-7220	9		RESISTOR 215 1% .05W F TC=0+-100	24546	C3-1/8-T0-215R-F
A3R29	0698-7212	9		RESISTOR 100 1% .05W F TC=0+-100	24546	C3-1/8-T0-100R-F
A3R30	1810-0273	9	2	NETWORK-RES 10-SIP470.0 OHM X 9	01121	210A471
A3R31	1810-0265	9	2	NETWORK-RES 16-DIP680.0 OHM X 8	01121	316B681
A3R32	1810-0265	9		NETWORK-RES 16-DIP680.0 OHM X 8	01121	316B681
A3R33	1810-0247	7	3	NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R34	0698-7232	3	1	RESISTOR 681 1% .05W F TC=0+-100	24546	C3-1/8-T0-681R-F
A3R35	1810-0247	7		NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R36	1810-0247	7		NETWORK-RES 16-DIP220.0 OHM X 8	01121	316B221
A3R37	0698-3430	5	9	RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R38	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R39	1810-0411	7	1	NETWORK-RES 10-SIP50.0 OHM X 9	56289	256CK500X2PD
A3R40	0757-0984	4	2	RESISTOR 10 1% .5W F TC=0+-100	28480	0757-0984
A3R41	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R42	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R43	0757-0984	4		RESISTOR 10 1% .5W F TC=0+-100	28480	0757-0984
A3R44	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R45	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R46	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R47	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R48	0698-3430	5		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A3R49	1810-0273	9		NETWORK-RES 10-SIP470.0 OHM X 9	01121	210A471
A3S1	3101-2172	0	1	SWITCH-TGL DIP-RKR-ASSY SPDT .05A 30VDC	28480	3101-2172
A3TP1	0360-0535	0	51	TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP9	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP10	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP11	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3TP12	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A3U1	1820-2075	4	3	IC MISC TTL LS	01295	SN74LS245N
A3U2	1820-2024	3	7	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U3	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U4	1820-1858	9	4	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U5	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U6	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U7	1820-1281	2	2	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A3U8	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A3U9	00438-80002	4	1	PROM PROGRAMMED	28480	00438-80002
A3U10	00438-80003	5	1	PROM PROGRAMMED	28480	00438-80003

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3U11	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U12	1818-1768	5	2	IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S0545	UPD446C-1(PER HP DWG)
A3U13	1818-1768	5		IC CMOS 16384 (16K) STAT RAM 150-NS 3-S	S0545	UPD446C-1(PER HP DWG)
A3U14	1820-1212	9	2	IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN
A3U15	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U16	1820-2483	8	1	IC RCVR TTL LS BUS OCTL	01295	SN75161N
A3U17	1820-2485	0	1	IC RCVR TTL LS BUS OCTL	01295	SN75160N
A3U18	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U19	1820-2624	9	1	IC-MPU; CLK FREQ=2MHZ, ENHANCED 6800	28480	1820-2624
A3U20	1820-2705	7	1	IC-8-BIT/16-BIT SYSTEM TIMING CONTROLLER	28480	1820-2705
A3U21	1820-2983	3	2	IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	28480	1820-2983
A3U22	1820-2983	3		IC-PERIPHERAL INTERFACE ADAPTER;CLK=2MHZ	28480	1820-2983
A3U23	1820-1427	8	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS156N
A3U24	1820-0668	7	5	IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U25	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U26	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U27	1820-1216	3	2	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U28	00438-80001	3	2	PAL PROGRAMMED	28480	00438-80001
A3U29	1820-2549	7	1	IC-8291A P HPIB	28480	1820-2549
A3U30	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U31	1820-1729	3	2	IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A3U32	1820-1729	3		IC LCH TTL LS COM CLEAR 8-BIT	01295	SN74LS259N
A3U33	1820-1281	2		IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A3U34	1820-1753	3	1	IC FF CMOS D-TYPE POS-EDGE-TRIG	27014	MM74C74N
A3U35	1826-0175	3	1	IC COMPARATOR GP DUAL 14-DIP-P PKG	27014	LM319N
A3U36	1820-1197	9	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A3U37	1820-1199	1	2	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A3U38	1820-1212	9		IC FF TTL LS J-K NEG-EDGE-TRIG	01295	SN74LS112AN
A3U39	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A3U40	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U41	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U42	1820-0668	7		IC BFR TTL NON-INV HEX 1-INP	01295	SN7407N
A3U43	1820-1851	2	1	IC ENCDR TTL LS	01295	SN74LS148N
A3U44	1820-2130	2	3	IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3U45	1820-2130	2		IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3U46	1820-2130	2		IC SWITCH CUR QUAD 16-DIP-P PKG	13606	ULN-2074B
A3Y1	1813-0130	3	1	IC OSC HYBRID	34344	K1148A-16.0MHZ
A4	00438-60004	4	1	INPUT AMPLIFIER ASSEMBLY	28480	00438-60004
A4C1	0180-2139	2	4	CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C2	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C3	0160-3336	1	5	CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A4C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4C5	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A4C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4C7	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C8	0180-2139	2		CAPACITOR-FXD 10UF+-20% 60VDC TA	06001	69F177G7
A4C9	0180-2206	4	4	CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C10	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C11	0160-0160	3	3	CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A4C12	0160-0160	3		CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A4C13	0180-0229	7	3	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C14	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C15	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C16	0180-2206	4		CAPACITOR-FXD 60UF+-10% 6VDC TA	56289	150D606X9006B2
A4C17	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C18	0180-0374	3		CAPACITOR-FXD 10UF+-10% 20VDC TA	56289	150D106X9020B2
A4C19	0180-0229	7		CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C20	0160-3439	5	3	CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A4C21	0160-3439	5		CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A4C22	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A4CR1	1901-0895	4	4	DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR2	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR3	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4CR4	1901-0895	4		DIODE-SM SIG SCHOTTKY	28480	1901-0895
A4J1	1251-5547	4	4	CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J2	1251-5286	8		CONNECTOR 4-PIN M POST TYPE	28480	1251-5286
A4J3	1251-8043	1	4	CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J4	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J5	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4J6	1250-1255	1	1	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-1255
A4J7	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J8	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J9	1251-8043	1		CONN-POST TYPE .100-PIN-SPCG 5-CONT	28480	1251-8043
A4J10	1251-7100	9	2	CONNECTOR 26-PIN M POST TYPE	28480	1251-7100
A4J11	1251-5547	4		CONNECTOR 6-PIN M POST TYPE	28480	1251-5547
A4J12	1251-0600	0	6	CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J13	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J14	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4J15	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A4L1	9100-3922	4	2	INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A4L2	9100-3922	4		INDUCTOR-FIXED 120-1300 HZ	28480	9100-3922
A4L3	9100-2247	4	1	INDUCTOR RF-CH-MLD 100NH 10% .105DX.26LG	28480	9100-2247
A4Q1	1854-0810	2	5	TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q2	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q3	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A4Q4	1853-0459	3	6	TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A4Q5	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A4R1	0811-1557	5	1	RESISTOR 15 5% 3W PW TC=0+-20	28480	0811-1557
A4R2	0757-0346	2	4	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R3	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R4	0698-3447	4	4	RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A4R5	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R6	0757-0346	2		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A4R7	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A4R8	0698-3450	9	5	RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R9	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R10	0757-0465	6	12	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R11	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R12	0698-3156	2	8	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A4R13	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A4R14	0757-0459	8	2	RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
A4R15	0757-0459	8		RESISTOR 56.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5622-F
A4R16	0698-3159	5	2	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A4R17	0698-3159	5		RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A4R18	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R19	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A4R20	0757-0444	1	3	RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A4R21	0757-0442	9	11	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R22	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A4R23	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R24	0757-0463	4	3	RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A4R25	0757-0463	4		RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A4R26	2100-2655	1	4	RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R27	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R28	0698-3451	0	2	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A4R29	0698-3451	0		RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A4R30	0698-3160	8	3	RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R31	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A4R32	0698-0083	8	2	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A4R33	0698-0083	8		RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A4R34	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R35	2100-2655	1		RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	82PR100K
A4R36	0698-0084	9	2	RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A4R37	0698-0084	9		RESISTOR 2.15K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2151-F
A4R38	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R39	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R40	0698-3154	0	3	RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A4R41	0757-0200	7	2	RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R42	0757-0460	1	2	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A4R43	2100-2030	6	1	RESISTOR-TRMR 20K 10% C TOP-ADJ 1-TRN	73138	82PR20K
A4R44	0757-0460	1		RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A4R45	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A4R46	0757-0200	7		RESISTOR 5.62K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5621-F
A4R47	0757-0279	0	3	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A4R48	0757-0280	3	11	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R49	0757-0422	5	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A4R50	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A4R51	0698-0085	0	2	RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R52	0698-0085	0		RESISTOR 2.61K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2611-F
A4R53	0698-3441	8	7	RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R54	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R55	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A4R56	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4TP1	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP9	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4TP10	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A4U1	1826-0547	3	2	IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	TL072ACP
A4U2	1826-1019	6	6	ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A4U3	1826-0547	3		IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-P	01295	TL072ACP
A4U4	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A4U5	1826-0600	9	3	IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A4VR1	1902-3002	3	4	DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR2	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR3	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4VR4	1902-3002	3		DIODE-ZNR 2.37V 5% DO-7 PD=.4W TC=-.074%	28480	1902-3002
A4W1	8159-0005	0	11	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W2	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W3	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W4	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W5	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W6	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W7				NOT ASSIGNED		
A4W8				NOT ASSIGNED		
A4W9	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W10	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W11	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A4W12	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A5	00438-60005	5	1	MAIN AMPLIFIER ASSEMBLY	28480	00438-60005
A5C1	0180-0291	3	7	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C2	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A5C3	0180-0197	8	5	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C4	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C5	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A5C7				NOT ASSIGNED		
A5C8	0160-0127	2	2	CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C9	0160-2290	4	1	CAPACITOR-FXD .15UF +-10% 80VDC POLYE	28480	0160-2290
A5C10	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C11	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C12	0160-3336	1		CAPACITOR-FXD 100PF +-10% 50VDC CER	28480	0160-3336
A5C13	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C14	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C15	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C16	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C17	0160-2199	2	3	CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C18	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C19	0160-3762	7	1	CAPACITOR-FXD .68UF +-5% 50VDC MET-POLYC	28480	0160-3762
A5C20	0160-3702	5	1	CAPACITOR-FXD .027UF +-5% 50VDC	28480	0160-3702
A5C21	0160-3402	2	2	CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC	28480	0160-3402
A5C22	0160-3661	5	2	CAPACITOR-FXD .1UF +-5% 50VDC MET-POLYC	28480	0160-3661
A5C23	0180-0373	2	2	CAPACITOR-FXD .68UF+-10% 35VDC TA	56289	150D684X9035A2
A5C24	0180-0373	2		CAPACITOR-FXD .68UF+-10% 35VDC TA	56289	150D684X9035A2
A5C25	0160-4557	0	1	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
A5C26	0160-3402	2		CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC	28480	0160-3402
A5C27	0160-3439	5		CAPACITOR-FXD .039UF +-5% 200VDC	28480	0160-3439
A5C28	0160-3661	5		CAPACITOR-FXD .1UF +-5% 50VDC MET-POLYC	28480	0160-3661
A5C29	0160-0160	3		CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A5C30	0160-4325	0	1	CAPACITOR-FXD .33UF +-5% 50VDC MET-POLYC	28480	0160-4325
A5C31	0160-0161	4	3	CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A5C32	0160-0168	1	1	CAPACITOR-FXD .1UF +-10% 200VDC POLYE	28480	0160-0168
A5C33	0160-0155	6	1	CAPACITOR-FXD 3300PF +-10% 200VDC POLYE	28480	0160-0155
A5C34	0160-2291	5	1	CAPACITOR-FXD .1UF +-10% 80VDC POLYE	28480	0160-2291
A5C35	0160-4638	8	1	CAPACITOR-FXD .1UF +-2% 100VDC	28480	0160-4638
A5C36	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5CR1	1901-0050	3	3	DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A5J1	1251-4700	9		CONNECTOR 3-PIN M POST TYPE	28480	1251-4700
A5J2	1251-4634	8		CONNECTOR 20-PIN M POST TYPE	28480	1251-4634
A5J3	1251-7100	9		CONNECTOR 26-PIN M POST TYPE	28480	1251-7100
A5J4	1250-1377	8	1	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-1377
A5L1	9140-0210	1	1	INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG	28480	9140-0210
A5MP1	0361-0009	5		RIVET-SEMITUB OVH .123 DIA .188LG	00000	ORDER BY DESCRIPTION
A5MP2	00438-20029	9		HINGE RIVETED	28480	00438-20029
A5Q1	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q2	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q3	1855-0420	2	1	TRANSISTOR J-FET 2N4391 N-CHAN D-MODE	01295	2N4391
A5Q4	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q5	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q6	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q7	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q8	1855-0414	4	1	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q9	1853-0314	9	1	TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	04713	2N2905A
A5R1	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A5R2	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R3	1810-0280	8		NETWORK-RES 10-SIP10.0K OHM X 9	01121	210A103
A5R4	0699-0842	9	2	RESISTOR 6.19K .1% .125W F TC=0+-25	28480	0699-0842
A5R5	0698-3444	1	2	RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A5R6	0757-0274	5	2	RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A5R7	0757-0439	4	1	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A5R8	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R9	0757-0123	3	2	RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A5R10	0757-0279	0		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A5R11	0698-8638	5	2	RESISTOR 3.16K .1% .125W F TC=0+-25	28480	0698-8638
A5R12	0698-8638	5		RESISTOR 3.16K .1% .125W F TC=0+-25	28480	0698-8638
A5R13	0699-0842	9		RESISTOR 6.19K .1% .125W F TC=0+-25	28480	0699-0842
A5R14	0757-0420	3	1	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A5R15	0699-0148	8	3	RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R16	0757-0290	5	1	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A5R17	0699-0924	8	1	RESISTOR 11K .1% .125W F TC=0+-25	28480	0699-0924
A5R18	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R19	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R20	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R21	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R22	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R23	0811-3351	1	1	RESISTOR 11K .025% .05W PWW TC=0+-10	28480	0811-3351
A5R24	0811-3348	6	2	RESISTOR 111.11 .025% .05W PWW TC=0+-10	28480	0811-3348
A5R25	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R26	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R27	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R28	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R29	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R30	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R31	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R32	0698-3158	4	4	RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R33	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R34	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R35	0698-3158	4		RESISTOR 23.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2372-F
A5R36	0698-3442	9	1	RESISTOR 237 1% .125W F TC=0+-100	24546	C4-1/8-T0-237R-F
A5R37	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R38	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R39	0698-3441	8		RESISTOR 215 1% .125W F TC=0+-100	24546	C4-1/8-T0-215R-F
A5R40	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A5R41	0757-0461	2	1	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A5R42	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R43	0757-0463	4		RESISTOR 82.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8252-F
A5R44	0698-3453	2	1	RESISTOR 196K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1963-F
A5R45	0757-0470	3	1	RESISTOR 162K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1623-F
A5R46	0757-0288	1	2	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A5R47	0698-3157	3	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A5R48	0698-3161	9	1	RESISTOR 38.3K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3832-F
A5R49	0757-0462	3	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
A5R50	0757-0444	1		RESISTOR 12.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1212-F
A5R51	0698-3162	0	1	RESISTOR 46.4K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4642-F
A5R52	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R53	0811-3350	0	1	RESISTOR 10K .025% .05W PWW TC=0+-10	28480	0811-3350
A5R54	0811-3349	7	1	RESISTOR 1K .025% .05W PWW TC=0+-10	28480	0811-3349
A5R55	0811-3348	6		RESISTOR 111.11 .025% .05W PWW TC=0+-10	28480	0811-3348

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R56	0698-3455	4	1	RESISTOR 261K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2613-F
A5R57	0757-0274	5		RESISTOR 1.21K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1211-F
A5R58	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R59	0698-6360	6	1	RESISTOR 10K .1% .125W F TC=0+-25	28480	0698-6360
A5R60	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A5R61	2100-3109	2	1	RESISTOR-TRMR 2K 10% C SIDE-ADJ 17-TRN	32111	43P202
A5R62	0757-0440	7	4	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A5R63	0757-0123	3		RESISTOR 34.8K 1% .125W F TC=0+-100	28480	0757-0123
A5R64	0699-0148	8		RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R65	0699-1172	0	1	RESISTOR:FXD 200K 0.1% -+50 PPM/OC	28480	0699-1172
A5R66	0698-3160	8		RESISTOR 31.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3162-F
A5R67	0698-3136	8	1	RESISTOR 17.8K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1782-F
A5R68	0698-3450	9		RESISTOR 42.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4222-F
A5R69	0757-0278	9	1	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A5R70	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R71	0699-0148	8		RESISTOR 31.6K .1% .1W F TC=0+-15	28480	0699-0148
A5R72	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5R73	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R74	0698-3449	6	1	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F
A5R75	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R76	0757-0441	8	1	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A5R77	0698-3150	6	1	RESISTOR 2.37K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2371-F
A5R78				NOT ASSIGNED		
A5R79	0757-0419	0	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A5R80	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R81	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R82	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R83	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A5R84	0698-3156	2		RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A5TP1- A5TP20	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A5U1	1826-0059	2	3	IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U2	1826-0471	2	3	IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5U3	1826-0861	4	1	IC CONV 10-B-D/A 16-DIP-P PKG	24355	AD7533LN
A5U4	1820-1997	7	5	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U5	1820-1934	2	2	IC CONV 8-B-D/A 16-DIP-C PKG	06665	DAC-08EQ
A5U6	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U7	1826-0098	9	1	IC COMPARATOR PRCN TO-99 PKG	27014	LM211H
A5U8	1826-0026	3	1	IC COMPARATOR PRCN TO-99 PKG	01295	LM311L
A5U9	1826-0471	2		IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5U10	1820-1934	2		IC CONV 8-B-D/A 16-DIP-C PKG	06665	DAC-08EQ
A5U11	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U12	1826-0544	8	1	V REF 8-DIP-C	04713	MC1403U
A5U13	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A5U14	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U15	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A5U16	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A5U17	1826-0574	6	1	IC OP AMP LOW-DRIFT TO-99 PKG	07263	UA714LHC
A5U18	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A5U19	1826-1021	0	1	ANALOG MULTIPLEXER CHNL 16 -DIP-P	28480	1826-1021
A5U20	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U21	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U22	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U23	1826-0600	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A5U24	1826-0600	9		IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P	01295	TL074ACN
A5U25	1826-1019	6		ANALOG SWITCH 4 SPST 16-CERDIP	28480	1826-1019
A5U26	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U27	1826-0059	2		IC OP AMP GP TO-99 PKG	01295	LM201AL
A5U28	1826-0471	2		IC OP AMP LOW-DRIFT TO-99 PKG	28480	1826-0471
A5VR1	1902-0680	7	3	DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
A5VR2	1902-0947	9	1	DIODE-ZNR 3.6V 5% DO-35 PD=.4W TC=-.036%	28480	1902-0947
A5VR3	1902-0680	7		DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
	3050-0079	3	2	WASHER-FL NM NO. 2 .094-IN-ID .188-IN-OD	28480	3050-0079
A6				NOT ASSIGNED		

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A7				NOT ASSIGNED		
A8	00438-60008	8	1	RECTIFIER ASSEMBLY	28480	00438-60008
A8C1	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A8C2	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A8C3	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A8CR1	1906-0231	2	1	DIODE-CT-RECT 200V 15A	28480	1906-0231
A8CR2	1901-0028	5	10	DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A8CR3	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A8MP1	0515-0064	9	6	SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP2	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP3	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP4	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP5	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP6	0515-0064	9		SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	28480	0515-0064
A8MP7	0590-1076	3	6	THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP8	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP9	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP10	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP11	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP12	0590-1076	3		THREADED INSERT-NUT M3 X 0.5 1.5-MM-LG	28480	0590-1076
A8MP13	1200-0081	4	6	INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP14	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP15	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP16	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP17	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP18	1200-0081	4		INSULATOR-FLG-BSHG NYLON	28480	1200-0081
A8MP19	1251-2313	6	6	CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP20	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP21	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP22	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP23	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP24	1251-2313	6		CONNECTOR-SGL CONT SKT .04-IN-BSC-SZ RND	28480	1251-2313
A8MP25	2190-0003	8	13	WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP26	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP27	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP28	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP29	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP30	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A8MP31	00438-20021	1	1	HEATSINK RECT.	28480	00438-20021
A8R1	0698-3438	3	1	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
A8U1	1826-0423	4	1	IC V RGLTR TO-3	27014	LM317K
A8U2	1826-0677	0	1	IC-LM338	28480	1826-0677
	6040-0239	9	3	LUBRICANT-GREASE SIL	05820	120
A9	00438-60009	9	1	REGULATOR ASSEMBLY	28480	00438-60009
A9C1	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C2	0160-0163	6	1	CAPACITOR-FXD .033UF +-10% 200VDC POLYE	28480	0160-0163
A9C3	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A9C4	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C5	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A9C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A9C7	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9C8	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A9C9	0160-3638	6	2	CAPACITOR-FXD .22UF +80-20% 200VDC CER	28480	0160-3638
A9C10	0160-4535	4	1	CAPACITOR-FXD 1UF +-10% 50VDC CER	28480	0160-4535
A9C11	0180-0491	5	1	CAPACITOR-FXD 10UF+-20% 25VDC TA	28480	0180-0491
A9C12	0180-1743	2	2	CAPACITOR-FXD .1UF+-10% 35VDC TA	56289	150D104X9035A2
A9C13	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A9CR1	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR2	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR3	1901-0418	7	3	DIODE-PWR RECT 400V 1.5A	28480	1901-0418
A9CR4	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR5	1901-0418	7		DIODE-PWR RECT 400V 1.5A	28480	1901-0418

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A9CR6	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR7	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR8	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A9CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2NS DO-35	28480	1901-0050
A9CR10	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A9CR11	1901-0418	7		DIODE-PWR RECT 400V 1.5A	28480	1901-0418
A9DS1	1990-0486	6	4	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS2	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS3	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9DS4	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A9MP1	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP2	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP3	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP4	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP5	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP6	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP7	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP8	0360-0535	0		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A9MP9	0515-0054	7	5	SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A9MP10	0515-0054	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A9MP11	0535-0004	9	9	NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A9MP12	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A9MP13	1205-0011	0	1	HEAT SINK TO-5/TO-39-CS	28480	1205-0011
A9MP14	1205-0353	3	3	HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A9MP15	1205-0353	3		HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A9MP16	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A9MP17	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A9MP18	3050-0105	6	7	WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A9MP19	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A9MP20	5000-9043	6	1	PIN:P.C. BOARD EXTRACTOR	28480	5000-9043
A9MP21	5040-6843	2	1	EXTRACTOR, P.C. BOARD	28480	5040-6843
A9MP22	08673-20063	2	2	BUSHING	28480	08673-20063
A9Q1	1884-0244	9	2	THYRISTOR-SCR VRRM=400	3L585	S2600D
A9Q2	1884-0244	9		THYRISTOR-SCR VRRM=400	3L585	S2600D
A9R1	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9R2	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R3	2100-2633	5	2	RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	30983	ET50X102
A9R4	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R5	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A9R6	0757-0418	9	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A9R7	0757-0397	3	1	RESISTOR 68.1 1% .125W F TC=0+-100	24546	C4-1/8-T0-68R1-F
A9R8	0757-0288	1		RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A9R9	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A9R10	0698-3447	4		RESISTOR 422 1% .125W F TC=0+-100	24546	C4-1/8-T0-422R-F
A9R11	0698-3154	0		RESISTOR 4.22K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4221-F
A9R12	0698-3444	1		RESISTOR 316 1% .125W F TC=0+-100	24546	C4-1/8-T0-316R-F
A9R13	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A9R14	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A9R15	0757-0398	4	2	RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
A9R16	2100-2633	5		RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN	30983	ET50X102
A9R17	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9R18	0757-1094	9		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A9U1	1826-0607	6	1	IC-REGULATOR 7815A	28480	1826-0607
A9U2	1826-0527	9	1	IC 337 V RGLTR TO-220	27014	LM337T
A9VR1	1902-0952	6	1	DIODE-ZNR 5.6V 5% DO-35 PD=.4W TC=+.046%	28480	1902-0952
A9VR2	1902-0176	6	1	DIODE-ZNR 47V 5% PD=1W IR=5UA	28480	1902-0176
	6040-0239	9		LUBRICANT-GREASE SIL	05820	120
A10	00438-60006	6	1	POWER SUPPLY INTERCONNECT ASSEMBLY	28480	00438-60006
A10C1	0180-3286	2	1	CAPACITOR-FXD .018+75-10% 15VDC AL	28480	0180-3286
A10C2	0180-3283	9	1	CAPACITOR-FXD 2200UF+75-10% 50VDC AL	28480	0180-3283
A10C3	0180-3282	8	1	CAPACITOR-FXD 680UF+100-10% 50VDC AL	28480	0180-3282
A10C4	0160-3638	6		CAPACITOR-FXD .22UF +80-20% 200VDC CER	28480	0160-3638
A10C5	0180-1743	2		CAPACITOR-FXD .1UF+-10% 35VDC TA	56289	150D104X9035A2
A10C6	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C7	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C8	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
A10C9	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A10CR1	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A10CR2	1901-0028	5		DIODE-PWR RECT 400V 750MA DO-29	28480	1901-0028
A10J1	1251-6855	9	1	CONNECTOR 8-PIN M POST TYPE	28480	1251-6855
A10J2	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A10J3	1251-0600	0		CONNECTOR-SGL CONT PIN 1.14-MM-BSC-SZ SQ	28480	1251-0600
A10J4	1251-3638	0	1	CONNECTOR 6-PIN M POST TYPE	28480	1251-3638
A10MP1	0515-0854	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A10MP2	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A10MP3	1205-0353	3		HEAT SINK SGL PLSTC-PWR-CS	13103	6073B
A10MP4				NOT ASSIGNED		
A10MP5				NOT ASSIGNED		
A10MP6	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
A10MP7	2200-0103	2	1	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
A10MP8	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
A10MP9	5040-0170	6	1	SUPPORT BOARD	28480	5040-0170
A10MP10	08673-20063	2		BUSHING	28480	08673-20063
A10TP1	0360-0535	8		TERMINAL TEST POINT PCB	00000	ORDER BY DESCRIPTION
A10U1	1826-0147	9	1	IC 7812 V RGLTR TO-220	04713	MC7812CP
A10W1	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A10XA8	1251-2026	8	2	CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	28480	1251-2026
A10XA9	1251-2026	8		CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS	28480	1251-2026
	6040-0239	9		LUBRICANT-GREASE SIL	05820	126
A11	00438-60007	7	1	HP-IB ASSEMBLY	28480	00438-60007
A11J1	1251-4833	9		CONNECTOR 34-PIN M POST TYPE	28480	1251-4833
A11J2	1251-3283	1	1	CONNECTOR 24-PIN F MICRORIBBON	28480	1251-3283
A11MP1	0380-0643	3	2	STANDOFF-HEX .255-IN-LG 6-32THD	00000	ORDER BY DESCRIPTION
A11MP2	0380-0643	3		STANDOFF-HEX .255-IN-LG 6-32THD	00000	ORDER BY DESCRIPTION
A11MP3	0515-0854	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A11MP4	0515-0854	7		SCREW-MACH M3 X 0.5 10MM-LG PAN-HD	28480	0515-0054
A11MP5	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A11MP6	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
A11MP7	1530-1098	4	2	CLEVIS 0.070-IN W SLT: 0.454-IN PIN CTR	00000	ORDER BY DESCRIPTION
A11MP8	1530-1098	4		CLEVIS 0.070-IN W SLT: 0.454-IN PIN CTR	00000	ORDER BY DESCRIPTION
A11MP9	2190-0019	6	2	WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0019
A11MP10	2190-0019	6		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0019
A11MP11	2190-0017	4	6	WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
A11MP12	2190-0017	4		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
A11S1	3101-1973	7	1	SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
				CHASSIS PARTS		
G1	00436-60010	0	2	50MHZ POWER REFERENCE OSCILLATOR ASSEMBLY (STANDARD)	28480	00436-60010
G1A1	00436-60011	1	2	50MHZ POWER REFERENCE OSCILLATOR ASSY	28480	00436-60011
G1A1C1	0160-3879	7	4	CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C2	0160-3036	8	2	CAPACITOR-FDTHRU 5000PF +80 -20% 200V	28480	0160-3836
G1A1C3	0160-3036	8		CAPACITOR-FDTHRU 5000PF +80 -20% 200V	28480	0160-3936
G1A1C4	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C5	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C6	0160-2207	3	1	CAPACITOR-FXD 300PF +-5% 300VDC MICA	28480	0160-2207
G1A1C7	0160-2204	0	1	CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
G1A1C8	0180-0100	3	1	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X9035B2
G1A1C9	0160-2255	1	1	CAPACITOR-FXD 8.2PF +-.25PF 500VDC CER	28480	0160-2255
G1A1C10	0160-3878	6	1	CAPACITOR-FXD 1000PF +-20% 100VDC CER	28480	0160-3878
G1A1C11	0160-2150	5	1	CAPACITOR-FXD 33PF +-5% 300VDC MICA	28480	0160-2150
G1A1C12	0160-3879	7		CAPACITOR-FXD .01UF +-20% 100VDC CER	28480	0160-3879
G1A1C13	0160-4006	4	1	CAPACITOR-FXD 36PF +-5% 300VDC GL	28480	0160-4006
G1A1C14	0160-4007	5	1	CAPACITOR-FXD 200PF +-5% 300VDC GL	28480	0160-4007
G1A1CR1	1901-0518	8	2	DIODE-SM SIG SCHOTTKY	28480	1901-0518
G1A1CR2	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
G1A1CR3	0122-0299	9	1	DIODE-VVC 82PF 5% C2/C20-MIN=2 BVR=20V	28480	0122-0299

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
G1A1J1	1250-1220	0	1	CONNECTOR-RF SMC M PC 50-OHM	28480	1250-1220
G1A1L1	00438-80001	3		COIL-VARIABLE	28480	00438-80001
G1A1L2	9140-0144	0	1	INDUCTOR RF-CH-MLD 4.7UH 10% .105DX.26LG	28480	9140-0144
G1A1L3	00436-80002	2	1	COIL-3-1/2 TURNS	28480	00436-80002
G1A1Q1	1854-0247	9	1	TRANSISTOR NPN SI TO-39 PD=1W FT=800MHZ	28480	1854-0247
G1A1Q2	1854-0071	7	1	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
G1A1R1	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
G1A1R2*	0757-1094	9	5	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
G1A1R3	0811-3234	9	1	RESISTOR 10K 1% .05W PWW TC=0+-10	20940	140-1/20-1002-F
G1A1R4	2100-3154	7	1	RESISTOR-TRMR 1K 10% C SIDE-ADJ 17-TRN	02111	43P102
G1A1R5	0811-3381	7	1	RESISTOR 7.1K 1% .05W PWW TC=0+-10	28480	0811-3381
G1A1R6	0757-0440	7		RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
G1A1R7	0698-7284	5	2	RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
G1A1R8	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
G1A1R9	0698-7284	5		RESISTOR 100K 1% .05W F TC=0+-100	24546	C3-1/8-T0-1003-F
G1A1R10	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
G1A1R11	0757-0280	3		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
G1A1R12	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
G1A1R13	0757-0438	3	1	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
G1A1R14	0757-0398	4		RESISTOR 75 1% .125W F TC=0+-100	24546	C4-1/8-T0-75R0-F
G1A1R15	0757-0317	7		RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
G1A1R16	0698-8581	7	1	RESISTOR 50.5 1% .125W F TC=0+-25	28480	0698-8581
G1A1TP1	0360-1514	7	2	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
G1A1TP2	0360-1514	7		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
G1A1U1	1826-0013	8	1	IC OP AMP LOW-NOISE TO-99 PKG	06665	SSS741CJ
G1A1U2	1820-0223	0	1	IC OP AMP GP TO-99 PKG	3L585	CA301AT
G1A1VR1	1902-0680	7		DIODE-ZNR 1N827 6.2V 5% DO-7 PD=.4W	24046	1N827
G1A1VR2*	1902-0956	0	1	DIODE-ZNR 8.2V 5% DO-35 PD=.4W TC=+.065%	28480	1902-0956
				G1A1 MISCELLANEOUS PARTS		
	2190-0008	3	4	WASHER-LK EXT T NO. 6 .141-IN-ID	28480	2190-0008
	2190-0009	4	8	WASHER-LK INTL T NO. 8 .168-IN-ID	28480	2190-0009
	2190-0124	4	1	WASHER-LK INTL T NO. 10 .195-IN-ID	28480	2190-0124
	2360-0209	7	4	SCREW-MACH 6-32 1-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2580-0002	4	8	NUT-HEX-DBL-CHAM 8-32-THD .085-IN-THK	28480	2580-0002
	2950-0078	7	1	NUT-HEX-DBL-CHAM 10-32-THD .067-IN-THK	28480	2950-0078
	3050-0079	3		WASHER-FL NM NO. 2 .094-IN-ID .188-IN-OD	28480	3050-0079
	7100-1204	9	1	CAN-RECT .72-IN-DP-OUT 1.959-IN-WD-OUT	28480	7100-1204
G2	00436-60010	0		50MHZ POWER REFERENCE OSCILLATOR ASSEMBLY (OPTION 002)	28480	00436-60010
G2A1	00436-60011	1		REPEAT PARTS OF G1A1 FOR G2A1 (OPT 002)	28480	00436-60011
B1	3160-0266	3	1	FAN-TBAX 36-CFM 6-16VDC	28480	3160-0266
C1	0160-4065	5	1	CAPACITOR-FXD .1UF +-20% 250VAC(RMS)	28480	0160-4065
C2	0160-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	28480	0160-4554
F1	2110-0012	1	1	FUSE .5A 250V NTD 1.25X.25 UL	28480	2110-0012
G3	3160-0310	8	1	MODULE-MOTOR CONTROL SPEED CONTROL FOR	D3976	3.431.036.01
J1				NSR, P/O W3		
J2				NSR, P/O W1		
J3				NSR, P/O W2		
J4				NSR, P/O W13 ONLY OPT.		
J5				NSR, P/O W14 ONLY OPT.		
J6				NSR, P/O W15 ONLY OPT.		
J7	1250-0083	1	1	CONNECTOR-RF BNC FEM SGL-HOLE-FR 50-OHM	28480	1250-0083
MP1	5020-8813	8	1	FRAME FRONT	28480	5020-8813
MP2	00438-00005	9	1	PANEL FRONT	28480	00438-00005
MP3	00438-20024	4	1	FRAME REAR	28480	00438-20024
MP4	5040-7203	0	1	TRIM STRIP	28480	5040-7203
MP5	5001-0438	7	2	TRIM SIDE 3 1/2	28480	5001-0438

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
MP6	5061-0014	1	1	COVER U SHAPE	28480	5061-0014
MP7	5060-9964	6	1	COVER BOTTOM	28480	5060-9964
MP8-						
MP12				NOT ASSIGNED		
MP13	1460-1345	5	2	TILT STAND SST	28480	1460-1345
MP14	00438-00003	7	1	PANEL REAR	28480	00438-00003
MP15	5040-7201	8	4	FOOT FULL 1/2 MOD	28480	5040-7201
MP16	00438-00004	8	1	SHIELD FAN	28480	00438-00004
MP17	0515-0252	7	4	SCREW-MACH M3 X 0.5 40MM-LG PAN-HD	28480	0515-0252
MP18	3050-0105	6		WASHER-FL MTLC NO. 4 .125-IN-ID	28480	3050-0105
MP19	2190-0003	8		WASHER-LK HLCL NO. 4 .115-IN-ID	28480	2190-0003
MP20	0535-0004	9		NUT-HEX DBL-CHAM M3 X 0.5 2.4MM-THK	00000	ORDER BY DESCRIPTION
MP21	2190-0016	3	1	WASHER-LK INTL T 3/8 IN .377-IN-ID PART OF J7	28480	2190-0016
MP22	2950-0043	8	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-IN-THK PART OF J7	00000	ORDER BY DESCRIPTION
MP23	6960-0009	1	1	PLUG-HOLE FL-HD FOR .438-D-HOLE BRS EXCEPT OPT. 002	28480	6960-0009
MP24	6960-0024	0	1	PLUG-HOLE FL-HD FOR .688-D-HOLE NYL	28480	6960-0024
MP25	5020-8831	0	2	SIDE STRUTS	28480	5020-8831
MP26-						
MP32				NOT ASSIGNED		
MP33	00438-00012	8	2	SUPPORT CABLE	28480	00438-00012
MP34-						
MP35				NOT ASSIGNED		
MP36	00438-00006	0	1	PANEL SUB	28480	00438-00006
MP37	00438-20020	0	1	SCREEN RFI	28480	00438-20020
MP38	00438-20023	3	1	WINDOW	28480	00438-20023
MP39	5040-6889	6	1	LIGHT PIPE 19MM	28480	5040-6889
MP40				NOT ASSIGNED		
MP41	00438-20032	4	1	SUPPORT BOTTOM (WINDOW)	28480	00438-20032
MP42	00438-20033	5	1	SUPPORT TOP S PNL	28480	00438-20033
MP43	00438-00012	8		SUPPORT CABLE FR PNL	28480	00438-00012
MP44	2190-0104	0	2	WASHER-LK INTL T 7/16 IN .439-IN-ID OPT 002 ONLY PART OF J1 & J6	28480	2190-0104
MP45	2950-0132	6	4	NUT-HEX-DBL-CHAM 7/16-28-THD .094-IN-THK OPT 002 ONLY PART OF J1 & J6	00000	ORDER BY DESCRIPTION
MP46	00436-20014	0	4	WASHER MOUNT CONN (PART OF J2 AND J3) J4 AND J5 (OPT. 002 ONLY)	28480	00436-20014
MP47	1251-3362	7	4	NUT-AUDIO CONN OPT 002 ONLY PART OF J2 & J3	28480	1251-3362
MP48	0510-1149	3	5	RETAINER-PUSH ON KB-TO-SHFT EXT PART OF WINDOW	28480	0510-1149
MP49	7120-3104	4	6	WIRE MARKER SGL-LTR=A PLSTC-SPR-CLP PVC	06229	C8P-LETTER A
MP50	7120-3105	5	6	WIRE MARKER SGL-LTR=B PLSTC-SPR-CLP PVC OPT 002 ONLY EXCEPT OPT 004	06229	C8P-LETTER B
MP51	0515-0410	9	4	SCREW-MACH M3 X 0.5 20MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP52	2200-0164	5	3	SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG	00000	ORDER BY DESCRIPTION
MP53	2200-0166	7	8	SCREW-MACH 4-40 .312-IN-LG 82 DEG	00000	ORDER BY DESCRIPTION
MP54	5041-1682	9	1	KEY CAP LINE	28480	5041-1682
MP55	0362-0227	1	2	CONNECTOR-SGL CONT SKT 1.14-MM-BSC-SZ	28480	0362-0227
MP56				NOT ASSIGNED		
MP57	0360-1190	5	1	TERMINAL-SLDR LUG PL-MTG FOR-#3/8-SCR	28480	0360-1190
MP58-						
MP74				NOT ASSIGNED		
MP75	00438-00001	5	1	DECK	28480	00438-00001
MP76	00438-20031	3	1	BOARD SUPPORT	28480	00438-20031
MP77	00438-20026	6	1	PUSHROD	28480	00438-20026
MP78	00438-20025	5	1	CLIP PUSHROD	28480	00438-20025
MP79	00438-00009	3	1	SUPPORT AMPLIFIER	28480	00438-00009
MP80				NOT ASSIGNED		
MP81	7120-4163	7	1	LABEL-WARNING .5-IN-WD 1-IN-LG AL	28480	7120-4163
MP82	00438-00002	6	1	SHIELD INPUT AMP	28480	00438-00002
MP83	0515-0356	2	8	SCREW-MACHINE ASSEMPLY M3.5 X 0.6	00000	ORDER BY DESCRIPTION
MP84	0515-0101	5	8	SCREW-MACH M3 X 0.5 22MM-LG PAN-HD	28480	0515-0101
MP85	0515-0211	8	25	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP86	0515-0212	9	10	SCREW-MACH M3.5 X 0.6 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP87	0515-0226	5	2	SCREW-MACH M2.5 X 0.45 6MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP88	0515-0306	2	4	SCREW-MACH M4 X 0.7 40MM-LG PAN-HD	28480	0515-0306
MP89	0515-0389	1	4	SCREW-MACHINE ASSEMPLY M3.5 X 0.6 8MM-LG	00000	ORDER BY DESCRIPTION
MP90	0515-0409	6	2	SCREW-MACH M3 X 0.5 16MM-LG PAN-HD	00000	ORDER BY DESCRIPTION
MP91	2200-0164	5		SCREW-MACH 4-40 .188-IN-LG UNCT 82 DEG OPT 002 ONLY FOR CABLE SUPPORT BRACKET	00000	ORDER BY DESCRIPTION
MP92	2360-0117	6	5	SCREW-MACH 6-32 .375-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
MP93	2360-0181	4	6	SCREW-MACH 6-32 .25-IN-LG 82 DEG	00000	ORDER BY DESCRIPTION
MP94	2510-0192	6	8	SCREW-MACH 8-32 .25-IN-LG 100 DEG	00000	ORDER BY DESCRIPTION
MP95	0535-0007	2	1	NUT-HEX DBL-CHAM M3.5 X 0.6 2.8MM-THK	00000	ORDER BY DESCRIPTION
MP96				NOT ASSIGNED		

See introduction to this section for ordering information

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
MP97				NOT ASSIGNED		
MP98	2190-0017	4		WASHER-LK HLCL NO. 8 .168-IN-ID	28480	2190-0017
MP99	1400-0053	4	1	CLAMP-CABLE .172-DIA .375-WD NYL	28480	1400-0053
MP100	1400-0510	8	2	CLAMP-CABLE .15-DIA .62-WD NYL OPTION 002 ONLY	28480	1400-0510
MP110	0515-0101	5		SCREW-MACH M3 X 0.5 22MM-LG PAN-HD	28480	0515-0101
S1	00438-60041	9	1	SWITCH PUSHBUTTON LINE ON OFF KIT	28480	00438-60041
T1	9100-4342	4	1	TRANSFORMER	28480	9100-4342
U1	0960-0043	7	1	LINE MODULE	28480	0960-0043
W1	00438-60020	4	2	CABLE ASSY FRONT A	28480	00438-60020
W2	00438-60020	4		CABLE ASSY FRONT B	28480	00438-60020
W3	00438-60026	0	2	CABLE ASSY REF OSC (PART OF J1) FROM G1 50MHZ REFERENCE OSCILLATOR TO J1 FRONT PANEL	28480	00438-60026
W4	00438-60033	9	1	CABLE ASSY KEYS FROM A3J4 TO A1 (60001)	28480	00438-60033
W5	00438-60031	7	1	CABLE ASSY DISPLAY FROM A3J5 TO A2J1	28480	00438-60031
W6	00438-60034	0		CABLE ASSY MICRO FROM A3J3 TO A5J2 (MAIN AMPLIFIER)	28480	00438-60034
W7	00438-60032	8	1	CABLE ASSY HP-IB FROM A3J1 TO A11 (60007) HP/IB	28480	00438-60032
W8	00438-60038	4	1	LINE SWITCH ASSY FROM S1 TO U1 (LINE MOD FILTER) & C1	28480	00438-60038
W9	00438-60027	1	1	W HRNS REDR-OUPT REAR PANEL BNC J7 TO A5J1 & LUG HAS GND	28480	00438-60027
W10	00438-60040	8	1	CABLE ASSY AMP SIG FROM A4J6 TO A5J4	28480	00438-60040
W11	00438-60035	1	1	CABLE ASSY ANALOG INP FROM A4J10 AMP INPUT TO A5J3 MAIN AMP	28480	00438-60035
W12	8120-1378	1	1	CABLE ASSY 18AWG 3-CNDCT JGK-JKT	28480	8120-1378
W13	00438-60022	6	2	CABLE ASSY REAR A PART OF J4 OPT 002 ONLY	28480	00438-60022
W14	00438-60022	6		CABLE ASSY REAR B PART OF J5 OPT 002 ONLY	28480	00438-60022
W15	00438-60026	0		CABLE ASSY REF OSC PART OF J6 OPT 002 ONLY	28480	00438-60026
W16	00438-60036	2	1	WIRING HARNESS FROM A10J1 INTERCONNECT TO A3J2, J6 MICROPROCESSOR & A4J2 INPUT AMPLIFIER	28480	00438-60036

See introduction to this section for ordering information

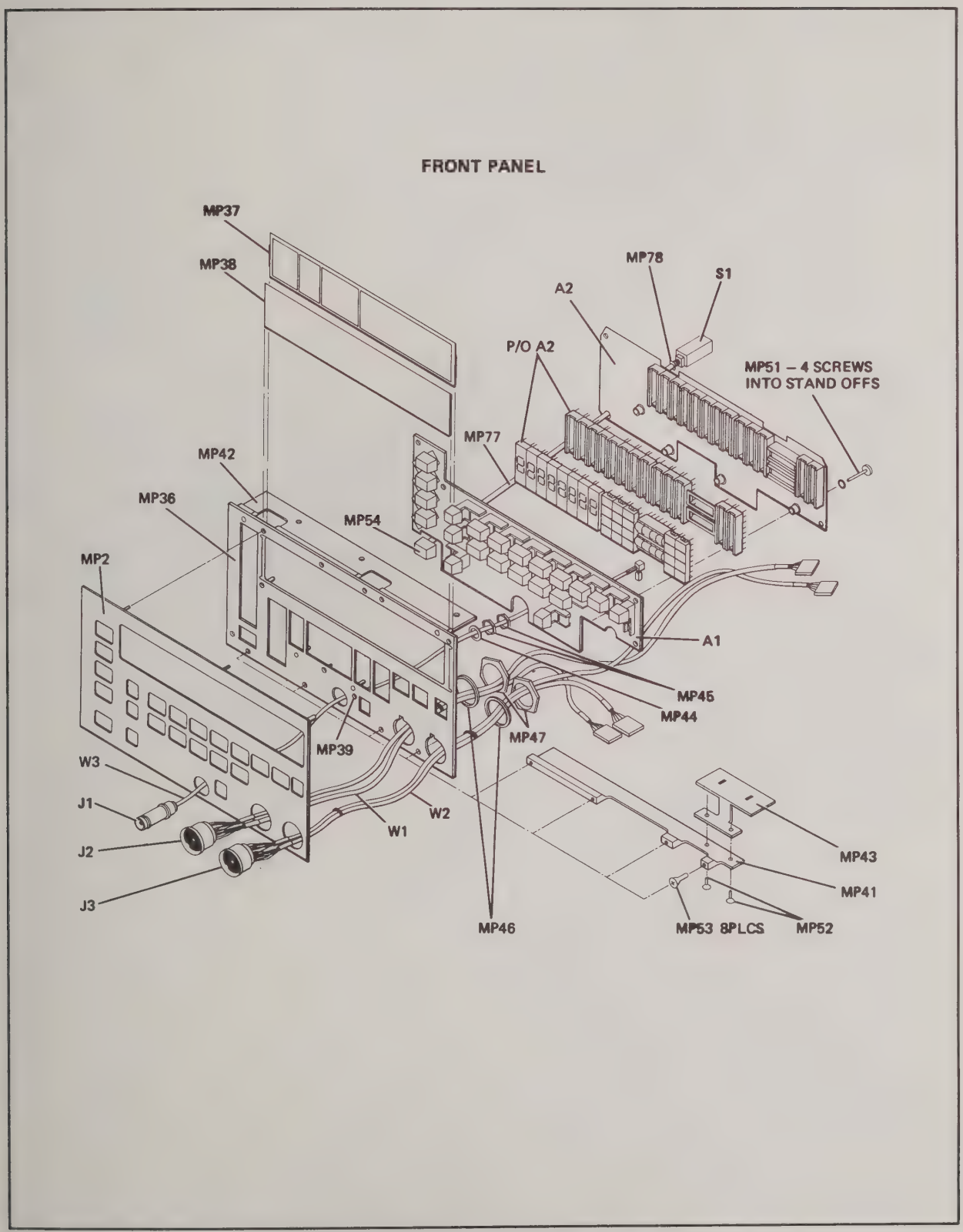


Figure 6-1. Front Panel Illustrated Parts Breakdown

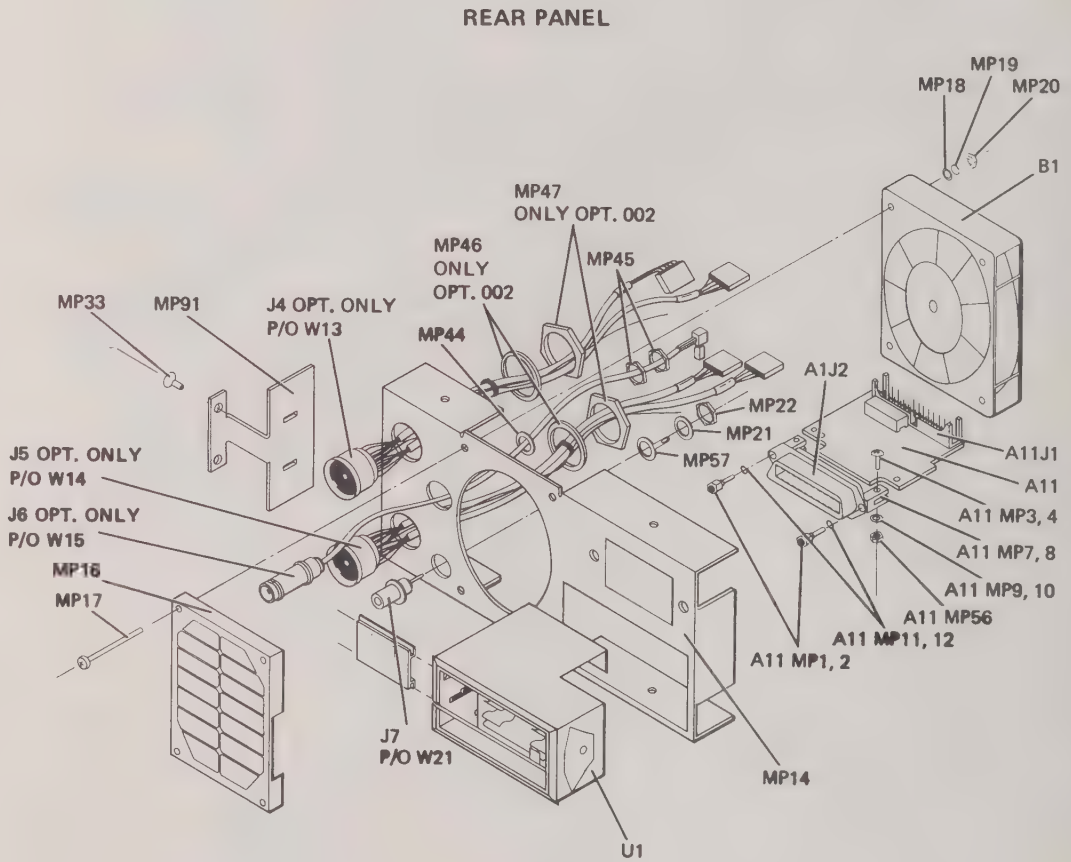


Figure 6-2. Rear Panel Illustrated Parts Breakdown

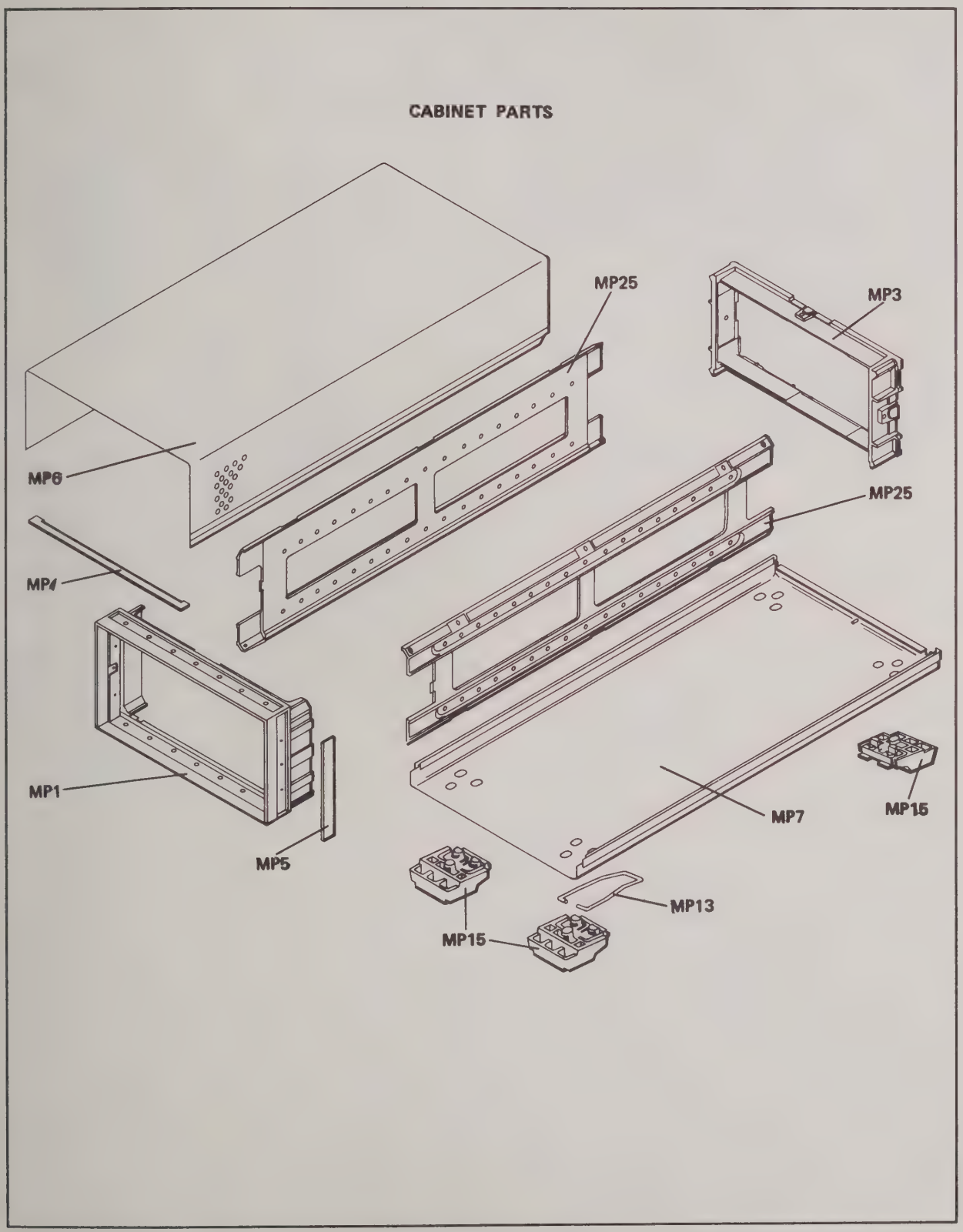


Figure 6-3. Cabinet Parts

Table 6-4. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address		Zip Code
D3976	BUEHLER GEBR NACHFOLGER GMBH	NURNBERG	GM	7750
S0545	NIPPON ELECTRIC CO	TOKYO	JP	
00000	ANY SATISFACTORY SUPPLIER			
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
02111	SPECTROL ELECTRONICS CORP	CITY OF IND	CA	91745
03888	K D I PYROFILM CORP	WHIPPANY	NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85008
05820	WAKEFIELD ENGINEERING INC	WAKEFIELD	MA	01880
06001	MEPCO ELECTRA CORP	COLUMBIA	SC	29063
06229	ELECTROVERT INC	ELMSFORD	NY	10553
06665	PRECISION MONOLITHICS INC	SANTA CLARA	CA	95050
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
13103	THERMALLOY CO	DALLAS	TX	75234
13606	SPRAGUE ELECT CO SEMICONDUCTOR DIV	CONCORD	NH	03301
16299	CORNING GLASS WKS COMPONENT DIV	RALEIGH	NC	27604
19701	MEPCO/ELECTRA CORP	MINERAL WELLS	TX	76067
20940	MICRO-OHM CORP	EL MONTE	CA	91731
24046	TRANSITRON ELECTRONIC CORP	WAKEFIELD	MA	01880
24355	ANALOG DEVICES INC	NORWOOD	MA	02062
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
25088	SIEMENS CORP	ISELIN	NJ	08830
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
3L585	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	
30983	MEPCO/ELECTRA CORP	SAN DIEGO	CA	92121
34344	MOTOROLA INC	FRANKLIN PARK	IL	60131
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
73138	BECKMAN INSTRUMENTS INC HELIPOT DIV	FULLERTON	CA	92634

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

This section normally contains information for adapting this manual to instruments for which the content does not apply directly. Since this manual does apply directly to instruments having serial numbers listed on the title page, no change information is given here. Refer to paragraph 1-4, Instruments Covered by this Manual, for additional important information about serial number coverage.

SECTION VIII

SERVICE

8-1. INTRODUCTION

This section contains information required for servicing the Power Meter. It includes block diagrams, and schematic diagrams.

8-2. SERVICE SHEETS

The foldout pages in the last part of this section are the service sheets(SS). They contain block diagrams, schematic diagrams, supplemental diagrams, and associated information.

8-3. Block Diagrams

The block diagrams and related service information are found on Service Sheets BD1,BD2 and BD3. BD1 is an overall block diagram that shows the major functional sections of the Power Meter. It serves as an index to the more detailed information on the succeeding Service Sheets, and is the starting point for most troubleshooting procedures. BD2 shows the Controller Section with connections to BD3 the Amplifier Section.

8-4. Schematic Diagrams

The schematic diagrams and their associated information are presented in Service Sheets 1 through 11. These diagrams, in functional groupings, are designed to aid in understanding the principles of operation and to aid in troubleshooting the Power Meter. Refer to the paragraph entitled Troubleshooting for additional information.

8-5. SAFETY CONSIDERATIONS

8-6. Before Applying Power

Verify that the instrument is properly set to operate from the available line voltage and that the correct fuse is installed. An uninterrupted safety earth ground must be provided from the main power source to the instrument input wiring terminals, power cord, or supplied power cord set.

8-7. Warnings and Cautions

Pay attention to the WARNINGS and CAUTIONS. They must be followed for your protection and to avoid damage to the equipment.

WARNINGS

Maintenance described herein must be performed with power supplied to the instrument and with protective covers removed. Such maintenance should be performed only by service trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Any interruption of the protective (grounding) conductor (inside or outside of the instrument) or disconnection of the protective earth terminal will create a potential shock hazard and could result in personal injury. Grounding one conductor of a two-conductor outlet is not sufficient. Whenever it is likely that the protection has been impaired, the instrument must be made inoperative (i.e., secured against unintended operation).

If the instrument is to be energized via an autotransformer, make sure that the common terminal of the autotransformer is connected to the earth terminal of the power source.

Capacitors inside the instrument may still be charged even if the instrument is disconnected from the power source.

Make sure that only 250 volt normal-blow fuses with the specified current rating are used for replacement. Do not used repaired fuses or short-circuited fuseholders. To do so could create a shock or fire hazard.

CAUTIONS

Some printed circuit boards contain devices that may be damaged if the board is removed or installed while the power is on. Verify that the LINE switch is OFF or that the power cord is unplugged before you remove or install a printed circuit board.

After removing MOS devices from sockets, store the devices with the pins in conductive foam. This will prevent accidental damage from a static discharge. Refer to the notes on each schematic diagram to identify the MOS devices.

8-8. RECOMMENDED TEST EQUIPMENT AND ACCESSORIES

Test equipment and test accessories required to maintain the Power Meter are listed in Table 1-3, Recommended Test Equipment. Equipment other than that listed may be used if it meets the critical specifications listed.

8-9. SERVICE TOOLS, AIDS, AND INFORMATION

8-10. Service Tools

Equipment recommended for use when changing components on printed circuit boards is listed in Table 8-1. The following unique service tools will make servicing of this instrument much easier.

POZIDRIV SCREWDRIVERS. Many screws in the Power Meter appear to be Phillips type, but they are not. To avoid damage to the screw heads, Pozidriv screwdrivers should be used. The Pozidriv No.1 size can be ordered as HP part number 8710-0899, and the Pozidriv No. 2 size can be ordered as HP part number 8710-0900.

TUNING TOOLS. For adjustments requiring non-metallic tuning tools, use the blade tuning tool HP part number 8710-0033 or hex tuning tool(JFD Model No. 5284) HP part number 8710-1010. For other adjustments, an ordinary small screwdriver is sufficient. No matter which tool is used, never force any adjustment control against its stops. This is especially critical when adjusting variable inductors or capacitors.

HEAT STAKING TOOL. The front-panel pushbutton switches have small plastic pins that protrude through the printed circuit board, and the pins are then flattened with a heated tool that softens the plastic. The heat staking tool is a standard soldering iron with a special tip attached.

HARDWARE. The Power Meter has a mixture of Unified National (inch) and metric screws. The metric screws are defined by Industrial Fasteners publication (IFI 500) and are identified in the replaceable parts list as metric. Unified National screws have a dull steel gray appearance and the metric screws have a shiny silver appearance. Do not use a metric screw in a Unified National nut, thread damage will result.

8-11. Assembly Locations

Printed circuit board assemblies are numbered sequentially from front to back. For example, A1 is part of the front panel assembly.

8-12. Parts and Cable Locations

The locations of individual components on the printed circuit boards and other assemblies are shown adjacent to the schematic diagrams on the appropriate Service Sheet. The complete reference designator consists of the assembly designator plus the part designator. For example, A6R9 is resistor R9 on the A6 assembly. For specific component descriptions and ordering information, refer to Table 6-3, Replaceable Parts. Chassis, frame, and other mechanical parts are identified in Figures 6-1 through 6-3.

Major mechanical parts have reference designators that begin with the letters MP. Other mechanical parts such a screws, washers, and nuts are listed in the replaceable parts list immediately below the part to which they fasten. To find the part number and description of a mechanical part, find the part in one of the figures in Section VI or Section VIII. The part in the figure will be labeled with its reference designator. Look up the reference designator in the Table of Replaceable Parts. If the part is fastening hardware such as a screw, washer, or nut, determine the reference designator of the associated part. The fastening hardware items will be listed immediately below the associated part.

8-13. Test Point and Adjustment Locations

Most test points and adjustments are indicated on individual circuit board assemblies. Test points and adjustments can also be found on the component locator diagrams adjacent to the assembly schematic diagrams.

8-14. Service Aids on Printed Circuit Boards

The service aids on the printed circuit boards include test points, indicator LEDs, reference designators, adjustment names, and assembly part numbers.

8-15. Other Service Documents

Service Notes, Manual Changes Supplements, Application Notes, and other service literature are available through Hewlett Packard. For further information, contact your nearest Hewlett Packard office.

8-16. TROUBLESHOOTING

8-17. General

Diagnostics that are designed into the Power Meter and executed on power up are the only troubleshooting procedures available at this time.

Table 8-1. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended	HP Part No.
Soldering Tool	Soldering, Heat Staking	Wattage: 35W Tip Temp.: 390°—440°C (735°—825°F)	Ungar No. 135 Ungar Division Eldon Ind. Corp. Compton, CA 90220	8690-0167
Soldering Tip	Soldering, Unsoldering	*Shape: Chisel	*Ungar PL113	8690-0007
Soldering Tip	Heat Staking	Shape: Cupped	HP 5020-8160 or modified Ungar PL111	5020-8160
De-Soldering Aid	To remove molten solder from connection	Suction Device	Soldapullt by Edsyn Co., Van Nuys, CA 91406	8690-0060
Rosin (flux) Solvent	To remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board.	Freon	8500-0232
Solder	Component replacement; Circuit Board repair wiring	Rosin (flux) core, high tin content (63/37 tin/lead), 18 gauge (SWG) 0.048 in. diameter preferred.		8090-0607

*For working on circuit boards, for general purpose work, use No. 555 Handle (8690-0261) and No. 4037 Heating Unit 47½ — 56½ W (HP 8690-0006); tip temperature of 850° — 900°F; and Ungar No. PL113 ⅛" chisel tip.

Table 8-2. Schematic Diagram Notes (1 of 8)

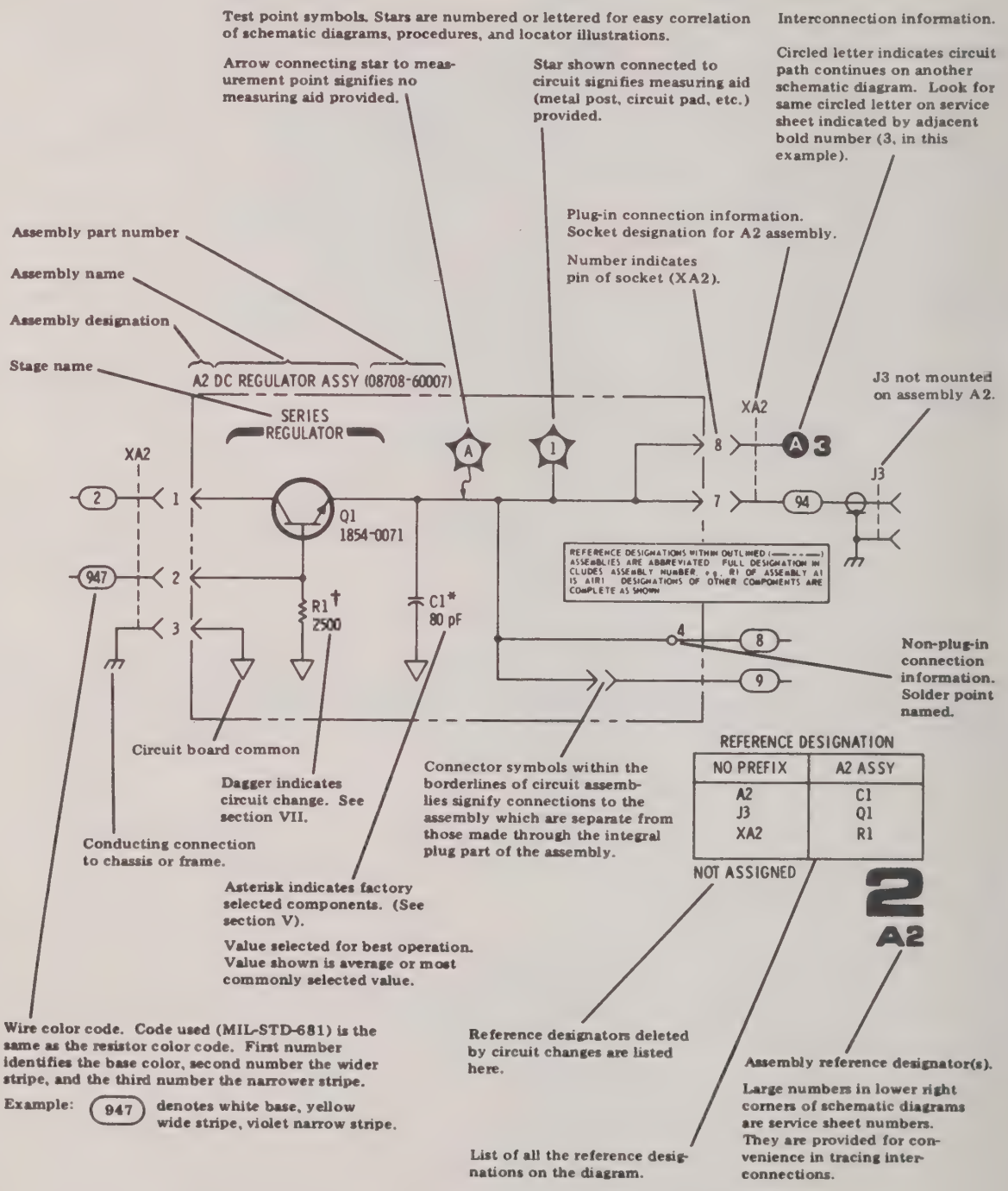
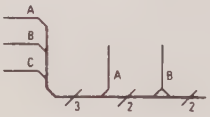

Test point symbols. Stars are numbered or lettered for easy correlation of schematic diagrams, procedures, and locator illustrations.
Arrow connecting star to measurement point signifies no measuring aid provided.
Star shown connected to circuit signifies measuring aid (metal post, circuit pad, etc.) provided.
Interconnection information.
Circled letter indicates circuit path continues on another schematic diagram. Look for same circled letter on service sheet indicated by adjacent bold number (3, in this example).
Plug-in connection information. Socket designation for A2 assembly.
Number indicates pin of socket (XA2).
Assembly part number
Assembly name
Assembly designation
Stage name
A2 DC REGULATOR ASSY (08708-60007)
SERIES REGULATOR
J3 not mounted on assembly A2.
XA2
J3
Q1
1854-0071
R1†
2500
C1*
80 pF
REFERENCE DESIGNATIONS WITHIN OUTLINED ASSEMBLIES ARE ABBREVIATED FULL DESIGNATION INCLUDES ASSEMBLY NUMBER e.g. R1 OF ASSEMBLY A1 IS A1R1 DESIGNATIONS OF OTHER COMPONENTS ARE COMPLETE AS SHOWN
Non-plug-in connection information. Solder point named.
Circuit board common
Dagger indicates circuit change. See section VII.
Connector symbols within the borderlines of circuit assemblies signify connections to the assembly which are separate from those made through the integral plug part of the assembly.
REFERENCE DESIGNATION
NO PREFIX
A2 ASSY
A2
J3
XA2
C1
Q1
R1
NOT ASSIGNED
Conducting connection to chassis or frame.
Asterisk indicates factory selected components. (See section V).
Value selected for best operation. Value shown is average or most commonly selected value.
Wire color code. Code used (MIL-STD-681) is the same as the resistor color code. First number identifies the base color, second number the wider stripe, and the third number the narrower stripe.
Example: 947 denotes white base, yellow wide stripe, violet narrow stripe.
Reference designators deleted by circuit changes are listed here.
List of all the reference designations on the diagram.
Assembly reference designator(s).
Large numbers in lower right corners of schematic diagrams are service sheet numbers. They are provided for convenience in tracing interconnections.

Table 8-2. Schematic Diagram Notes (2 of 8)

SCHEMATIC DIAGRAM NOTES

*	Asterisk denotes a factory-selected value. Value shown is typical.
†	Dagger indicates circuit change. See Section VII.
	Tool-aided adjustment. Manual control.
	Encloses front-panel designation.
	Encloses rear-panel designation.
	Circuit assembly borderline.
	Other assembly borderline.
	Heavy line with arrows indicates path and direction of main signal.
	Heavy dashed line with arrows indicates path and direction of main feedback.
	Indicates stripline (i.e., RF transmission line above ground).
	Wiper moves toward cw with clockwise rotation of control (as viewed from shaft or knob).
	Numbered Test Point measurement aid provided.
	Encloses wire or cable color code. Code used is the same as the resistor color code. First number identifies the base color, second number identifies the wider stripe, and the third number identifies the narrower stripe, e.g., denotes white base, yellow wide stripe, violet narrow stripe.
	A direct conducting connection to earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).
	A conducting connection to a chassis or frame.
	Common connections. All like-designation points are connected.
	Letters = off-page connection, e.g., AK Number = Service Sheet number for off-page connection, e.g., **12**
	Number (only) = on-page connection.

SCHEMATIC DIAGRAM NOTES



Indicates multiple paths represented by only one line. Letters or names identify individual paths. Numbers indicate number of paths represented by the line.

Coaxial or shielded cable.

Relay. Contact moves in direction of arrow when energized.

Indicates a pushbutton switch with a momentary (ON) position.

Indicates a PIN diode.

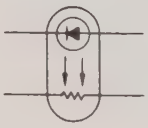
Indicates a current regulation diode.

Indicates a voltage regulation diode.

Indicates a Schottky (hot-carrier) diode.

Multiple transistors in a single package—physical location of the pins is shown in package outline on schematic.

Identification of logic families as shown (in this case, ECL).

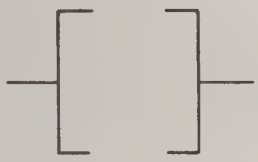


Indicates an opto-isolator of a LED and a photoresistor packaged together. The resistance of the photoresistor is a function of the current flowing through the LED.

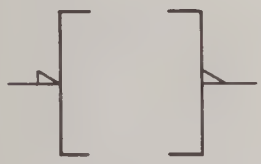
Table 8-2. Schematic Diagram Notes (4 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators



Implied Indicator—Absence of polarity indicator (see below) implies that the active state is a relative high voltage level. Absence of negation indicator (see below) implies that the active state is a relative high voltage level at the input or output.

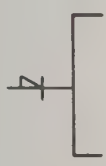


Polarity Indicator—The active state is a relatively low voltage level.

Dynamic Indicator—The active state is a transition from a relative low to a relative high voltage level.

Inhibit Input—Input that, when active, inhibits (blocks) the active state outputs of a digital device.

Analog Input—Input that is a continuous signal function (e.g., a sine wave).



Polarity Indicator used with Inhibit Indicator—Indicates that the relatively low level signal inhibits (blocks) the active state outputs of a digital device.

Output Delay—Binary output changes state only after the referenced input (m) returns to its inactive state (m should be replaced by appropriate dependency or function symbols).

Open Collector Output—Output that must form part of a distributed connection.

Table 8-2. Schematic Diagram Notes (5 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Input and Output Indicators (Cont'd)

3-STATE	Three-state Output—Indicates outputs that can have a high impedance (disconnect) state in addition to the normal binary logic states.

Combinational Logic Symbols and Functions

&	AND—All inputs must be active for the output to be active.
≥1	OR—One or more inputs being active will cause the output to be active.
≥m	Logic Threshold—m or more inputs being active will cause the output to be active (replace m with a number).
=1	EXCLUSIVE OR—Output will be active when one (and only one) input is active.
=m	m and only m—Output will be active when m (and only m) inputs are active (replace m with a number).
=	Logic Identity—Output will be active only when all or none of the inputs are active (i.e., when all inputs are identical, output will be active).
	Amplifier—The output will be active only when the input is active (can be used with polarity or logic indicator at input or output to signify inversion).
X/Y	Signal Level Converter—Input level(s) are different than output level(s).
	Bilateral Switch—Binary controlled switch which acts as an on/off switch to analog or binary signals flowing in both directions. Dependency notation should be used to indicate affecting/affected inputs and outputs. Note: amplifier symbol (with dependency notation) should be read to indicate unilateral switching.
X→Y	Coder—Input code (X) is converted to output code (Y) per weighted values or a table.
(Functional Labels)	The following labels are to be used as necessary to ensure rapid identification of device function.
MUX	Multiplexer—The output is dependent only on the selected input.
DEMUX	Demultiplexer—Only the selected output is a function of the input.
CPU	Central Processing Unit
PIO	Peripheral Input/Output
SMI	Static Memory Interface

Table 8-2. Schematic Diagram Notes (6 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions

1	Monostable—Single shot multivibrator. Output becomes active when the input becomes active. Output remains active (even if the input becomes inactive) for a period of time that is characteristic of the device and/or circuit.
G	Oscillator—The output is a uniform repetitive signal which alternates between the high and low state values. If an input is shown, then the output will be active if and only if the input is in the active state.
FF	Flip-Flop—Binary element with two stable states, set and reset. When the flip-flop is set, its outputs will be in their active states. When the flip-flop is reset, its outputs will be in their inactive states.
T	Toggle Input—When active, causes the flip-flop to change states.
S	Set Input—When active, causes the flip-flop to set.
R	Reset Input—When active, causes the flip-flop to reset.
J	J Input—Analogous to set input.
K	K Input—Analogous to reset input.
D	Data Input—Always enabled by another input (generally a C input—see Dependency Notation). When the D input is dependency-enabled, a high level at D will set the flip-flop; a low level will reset the flip-flop. Note: strictly speaking, D inputs have no active or inactive states—they are just enabled or disabled.
m	Count-Up Input—When active, increments the contents (count) of a counter by "m" counts (m is replaced with a number).
−m	Count-Down Input—When active, decrements the contents (count) of a counter by "m" counts (m is replaced with a number).
→ m	Shift Right (Down) Input—When active, causes the contents of a shift register to shift to the right or down "m" places (m is replaced with a number).
← m	Shift Left (Up) Input—When active, causes the contents of a shift register to shift to the left or up "m" places (m is replaced with a number).

NOTE

For the four functions shown above, if m is one, it is omitted.

(Functional Labels)	The following functional labels are to be used as necessary in symbol build-ups to ensure rapid identification of device function.

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Sequential Logic Functions (Cont'd)

mCNTR	Counter—Array of flip-flops connected to form a counter with modulus m (m is replaced with a number that indicates the number of states: 5 CNTR, 10 CNTR, etc.).
REG	Register—Array of unconnected flip-flops that form a simple register or latch.
SREG	Shift Register—Array of flip-flops that form a register with internal connections that permit shifting the contents from flip-flop to flip-flop.
ROM	Read Only Memory—Addressable memory with read-out capability only.
RAM	Random Access Memory—Addressable memory with read-in and read-out capability.

Dependency Notation

mAm	Address Dependency—Binary affecting inputs of affected outputs. The m prefix is replaced with a number that differentiates between several address inputs, indicates dependency, or indicates demultiplexing and multiplexing of address inputs and outputs. The m suffix indicates the number of cells that can be addressed.
Gm	Gate (AND) Dependency—Binary affecting input with an AND relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or letter (the identifier).
Cm	Control Dependency—Binary affecting input used where more than a simple AND relationship exists between the C input and the affected inputs and outputs (used only with D-type flip-flops).
Vm	OR Dependency—Binary affecting input with an OR relationship to those inputs or outputs labeled with the same identifier. The m is replaced with a number or the letter (the identifier).
Fm	Free Dependency—Binary affecting input acting as a connect switch when active and a disconnect when inactive. Used to control the 3-state behavior of a 3-state device.

NOTE

The identifier (m) is omitted if it is one—that is, when there is only one dependency relationship of that kind in a particular device. When this is done, the dependency indicator itself (G, C, F, or V) is used to prefix or suffix the affected (dependent) input or output.

Table 8-2. Schematic Diagram Notes (8 of 8)

DIGITAL SYMBOLOGY REFERENCE INFORMATION

Miscellaneous

Schmitt Trigger—Input characterized by hysterisis; one threshold for positive going signals and a second threshold for negative going signals.

Active

Active State—A binary physical or logical state that corresponds to the true state of an input, an output, or a function. The opposite of the inactive state.

Enable

Enabled Condition—A logical state that occurs when dependency conditions are satisfied. Although not explicitly stated in the definitions listed above, functions are assumed to be enabled when their behavior is described. A convenient way to think of it is as follows:

A function becomes active when:

- it is enabled (dependency conditions—if any—are satisfied)
- and its external stimuls (e.g., voltage level) enters the active state.

OVERALL BLOCK DIAGRAM SERVICE SHEET BD1

PRINCIPLES OF OPERATION

General

The Power Meter is a microprocessor controlled dual channel power meter with a built in 1 mW 50 MHz power reference. Figure 8-1 shows a simplified overall diagram of the Power Meter. For purposes of explanation and troubleshooting the Power Meter is divided into the following three functional sections:

1. The Controller section.
2. The Amplifier section.
3. The Power Supply section.

The Controller enables the functions that are requested by pressing front panel keys (local operation) or by HP-IB program codes (remote operation). The overall power range and frequency response of the Power Meter is determined by the power sensor(s) that are connected to channel A and/or channel B.

Under microprocessor control, the analog power inputs from the power sensors are measured and digitized by the amplifier section. The measurement result is used by the controller section to calculate and display the requested functions.

The following discussion explains Figure 8-6 Overall Block Diagram shown on Service Sheet BD1.

Controller Section

The microprocessor based Controller consists of the following assemblies:

1. A1 Keyboard Assembly.
2. A2 Display Assembly.
3. A3 Central Processing Unit (CPU).
4. A11 HP-IB Assembly.

The CPU provides the timing, calculation, and control for the instrument. The microprocessor executes instructions stored in the read only memory (ROM). Data is exchanged between the microprocessor and the other blocks of the CPU over the data bus

(D0-D7). The elememts of the CPU are enabled to respond to the data on the data bus by control signals. These signals are derived from the address bus (A0-A15) by the address and control decoders. Data values that must be stored are placed in the random access memory (RAM).

The CPU sends and receives data to and from other assemblies through the keyboard interface, HP-IB interface, and the analog input/output interface. It also sends data to the display through the display interface. The display indicates the current status of the Power Meter. This status information can consist of the current measurement configuration and results, or one of the error messages contained in Table 3-2 .

A simplified flowchart of the interrupt control program for the Power Meter is shown in Figure 8-2. Note that there are no asynchronous interrupts. The key to understanding the operation of the software is to understand that the software is interrupted at 1 ms intervals by a hardware generated interrupt. During these 1 ms intervals the software accomplishes the required configuration changes, calculations, and updates to perform all of the Power Meter's defined functions.

The software has the following three main routines:

1. The interrupt routine provides synchronous control of all Power Meter functions.

2. The task 1 routine primarily handles user commands (both front panel and HP-IB). A flowchart of the Task 1 routine is shown in Figure 8-3.

3. The task 2 routine primarily handles the mathematical calculations for the required measurement results and sets error flags when required. A flowchart of the Task 2 routine is shown in Figure 8-4.

When the instrument powers up, the status byte is set to 0 and a GT2 command is executed (refer to Section III for an explanation of the status byte and the GT2 command). After power up, hardware generated interrupts occur every 1 ms. Each interrupt causes the interrupt routine to perform the following functions:

1. Scan the keyboard inputs to determine if a key has been pressed. This subroutine also debounces the keyboard input by verifying that after approximately 10 ms the same key pressed indication is still present.

2. Refresh the front panel display information. This sequence does not change any information, it only allows the display to be refreshed at a rate that provides flicker free operation.

3. Start and monitor the analog to digital conversion (ADC). Once the ADC is started its operation is independent of the software. Additional information on the operation of the ADC is contained in Service Sheet BD3.

4. Input the power measurement value to the digital filter when required. The digital filter is updated every 50 ms (every 50 interrupts). This update rate is maintained regardless of the state of the instrument, HP-IB activity, or front panel activity.

When the interrupt routine is finished, it returns to either task 1 or 2. The software logic requires that the returns alternate between task 1 and task 2 and that it pass control to the task that was not interrupted. This allows both tasks to have an equal amount of execution time independent of what each is working on. This method of sharing execution time ensures that a high level of HP-IB activity does not slow down mathematical calculations nor does mathematical activity slow down the HP-IB response time.

When task 1 is executing, it performs the following functions:

1. Determine if any HP-IB function is pending and, if it is, perform it. These functions can consist of sending or receiving data over HP-IB or executing HP-IB commands.

2. Determine if any keyboard command is pending and, if it is, perform it. All key functions have individual routines that are performed each time the key is pressed.

3. Determine if there is new data available. This data can be an updated measurement result, new Power Meter configuration, or an error message. If there is new data, the display data buffers are updated and the new information is displayed when the display is refreshed during the interrupt routine.

When task 2 is executing, it performs the following functions:

1. Gets the last measurement result from the software digital filter. This output is the average output of the digital filter at that time. A detailed explanation of the digital filter is contained in Service Sheet BD3.

2. Checks to determine if any error conditions exist. Some error conditions can be cleared by updating the hardware configuration. For example, the Power Meter can autorange to a different range as required. If the error is cleared, task 2 loops back and begins again. If the error can not be cleared, an error flag is set and the appropriate error message is passed to task 1.

3. If no error condition exists, the measurement result is formatted and passed to task 1.

Note that either task 1 or 2 continues to run until the next 1 ms interrupt. The interrupt routine is then executed and the sequence repeated for the other task.

When the Power Meter is in local operation the keyboard can be used to select the required measurement configuration. The instrument remembers the last measurement configuration entered prior to turning off power and returns to that configuration when power is turned on.

When the Power Meter is in remote operation, with local lockout set all front panel keys except the LINE ON/OFF are disabled. The measurement configuration is selected by programmed inputs applied through the HP-IB. Remote operation can only be enabled via HP-IB.

Amplifier Section

The Amplifier Section consists of the following assemblies:

1. A4 Input Amplifier.
2. A5 Main Amplifier.
3. G1 50 MHz Reference Amplifier.

In addition, Option 002 adds two rear panel sensor input ports in parallel with front panel inputs and a second 50 MHz Reference Amplifier (G2) with an output on the rear panel.

All of the operating functions of the Amplifier Section are enabled and sequenced by the control signals from the CPU. As required, the correct sensor input is applied through channel A or B of the A4 Input Amplifier Assembly to the A5 Main Amplifier Assembly. The primary function of the main amplifier is to selectively attenuate, amplify, filter, and digitize the input signal under the direction of the CPU. This allows the CPU to obtain the neccessary data to compute and display the measurement results.

In addition to the primary signal flow, other signals, such as the power sensor resistor signal, can be applied through the multiplexer and digitized. The CPU uses the results of these measurements to determine if any changes or corrections are required.

The 50 MHz Reference Oscillator (G1) is enabled by the CPU when either the OSC or entry mode CAL ADJ (calibration) key is

pressed. The oscillator is turned off manually if the OSC key is pressed again or automatically at the end of the calibration cycle. If the optional rear panel reference oscillator is installed, both oscillators are turned on and off at the same time. Each oscillator provides an independent 1 mW 50 MHz output that can be used for calibration or as a signal source when troubleshooting.

Power Supply Section

The following five power supplies are used to prevent any interaction between different sections of the Power Meter:

1. The +5V digital power supply.
2. The pulsed +5V display power supply. This power supply is enabled by the CPU timer circuit.
3. The +15V analog power supply.
4. The --15V analog power supply.
5. The +10.4V power supply for the fan.

Because of the high precision requirements, the Power Meter not only uses separate power supplies but also uses separate grounding points for each type of digital and analog signal. Grounding is very important. There is only one defined ground point and that is at the rear panel RCDR BNC connector. See Figure 8-5 for a simplified diagram of the distribution of the grounds used on the different boards. The grounds are defined as follows:

1. The main instrument ground at the RCDR BNC connector.
2. The A GND is defined as the ground at the sensor bulkhead that is supplying the input being measured. The A GND is not a true ground. It is a reference for the signal being amplified through the bandpass amplifiers. The A GND is created on the A5 Main Amplifier Assembly and applied to the A4 Input Amplifier Assembly. A detailed explanation of the creation of the A GND is provided on Service Sheet 8.
3. The B GND is the low current analog ground. It is applied directly to the main amplifier from the main instrument ground. It is used on the main amplifier filters and the ADC.
4. The C GND is the high current main analog ground. The C GND is tied to the main instrument ground on the A9 Regulator Assembly and is used on the input amplifier and main amplifier assemblies.

5. The D GND is the main digital ground. The D GND is tied to the main instrument ground on the A10 Interconnect Assembly and is applied to the A3 Central Processing Unit Assembly. From the CPU it is applied to the main amplifier.

6. The display ground is the ground for the display drivers. The display ground is tied to the main instrument ground on the A10 Interconnect Assembly. It is applied to the CPU display driver circuits and used only by the +5V pulsed power supply.

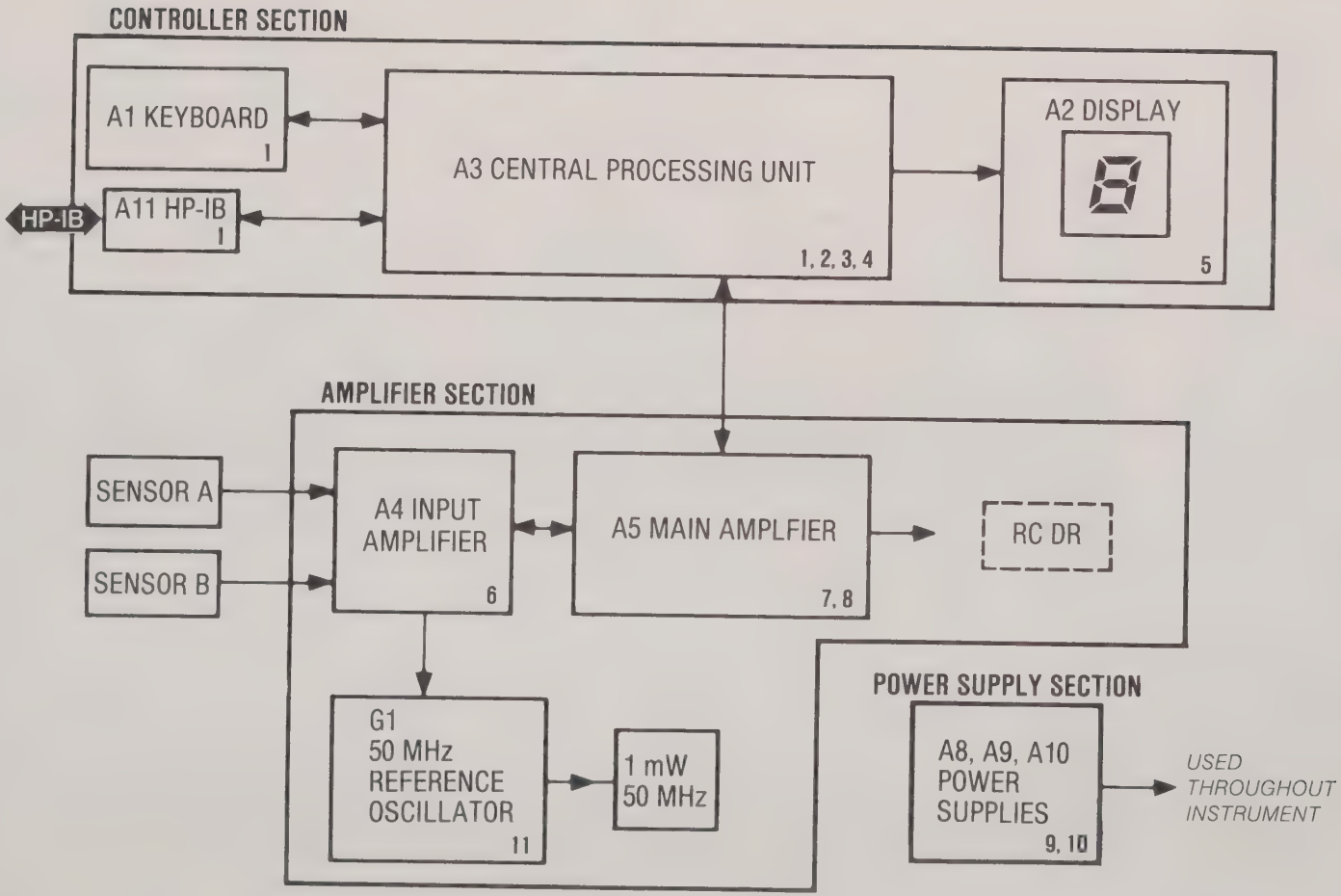


Figure 8-1. Power Meter Simplified Overal Diagram

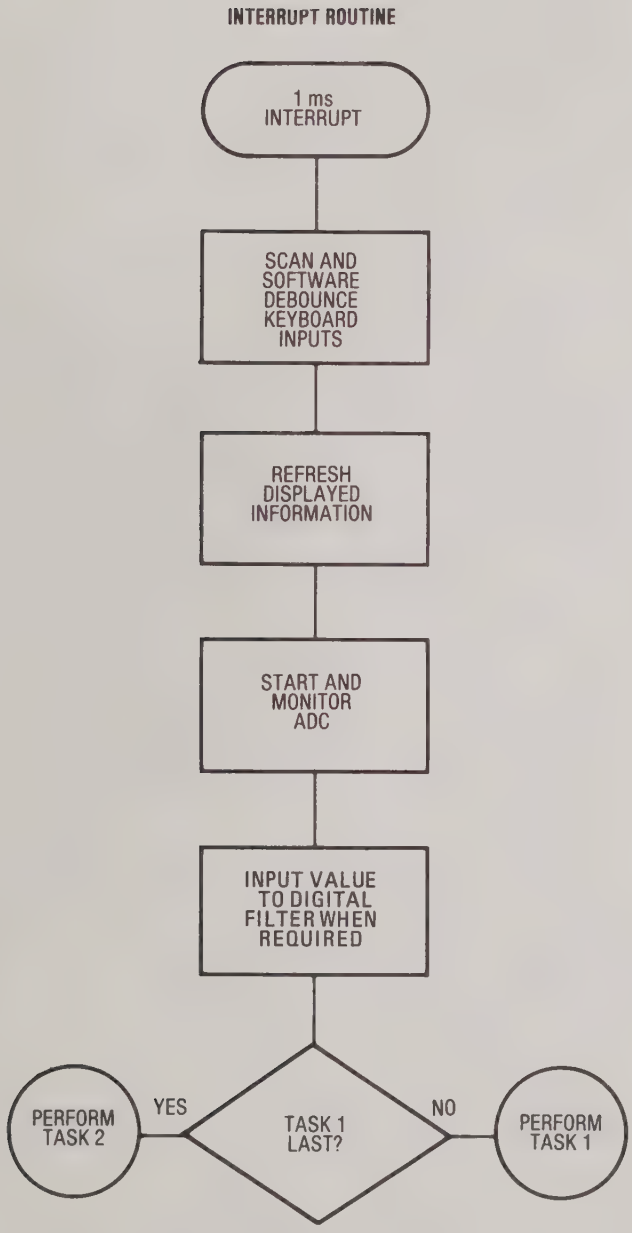


Figure 8-2. Interrupt Routine Flowchart

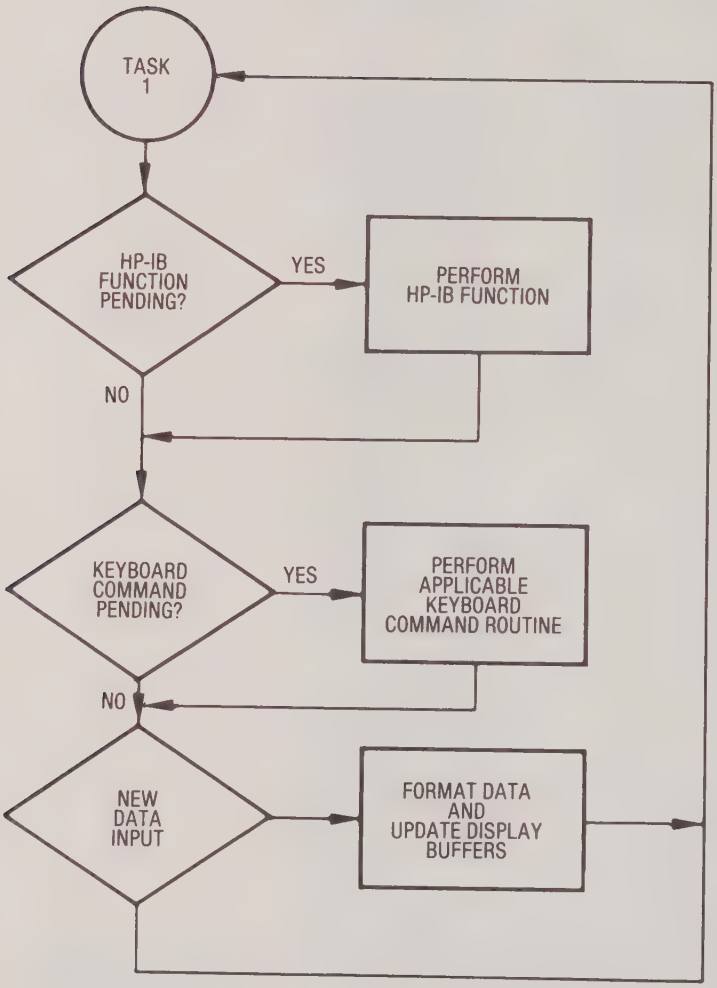


Figure 8-3. Task 1 Flowchart

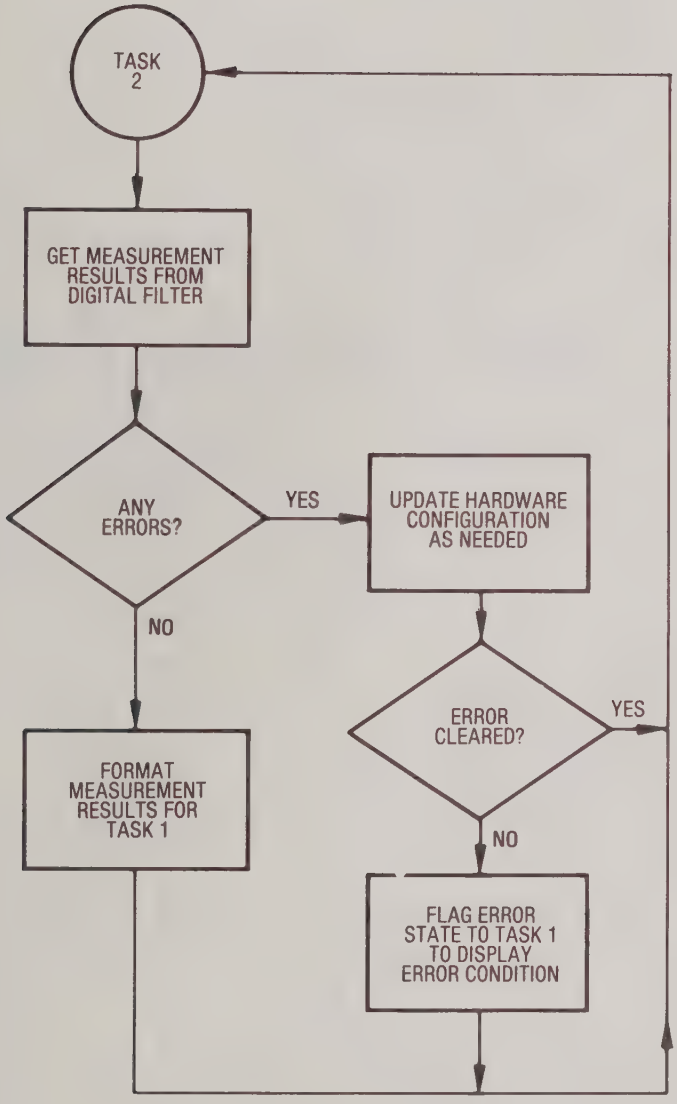


Figure 8-4. Task 2 Flowchart

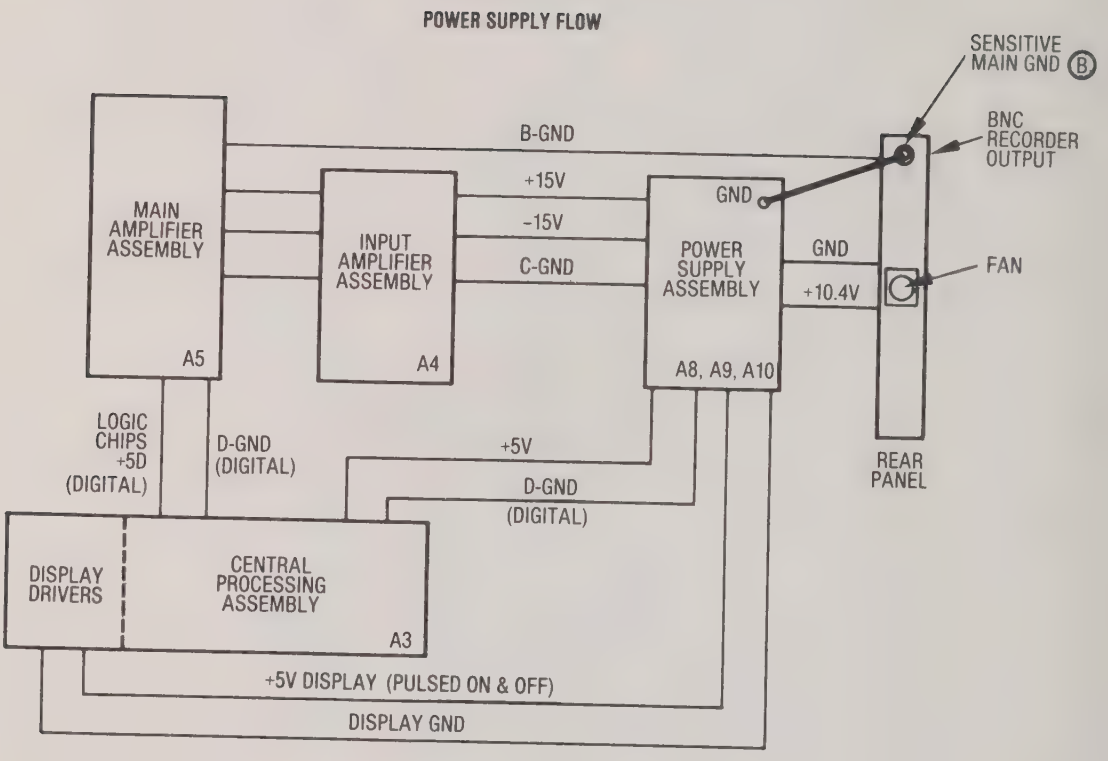
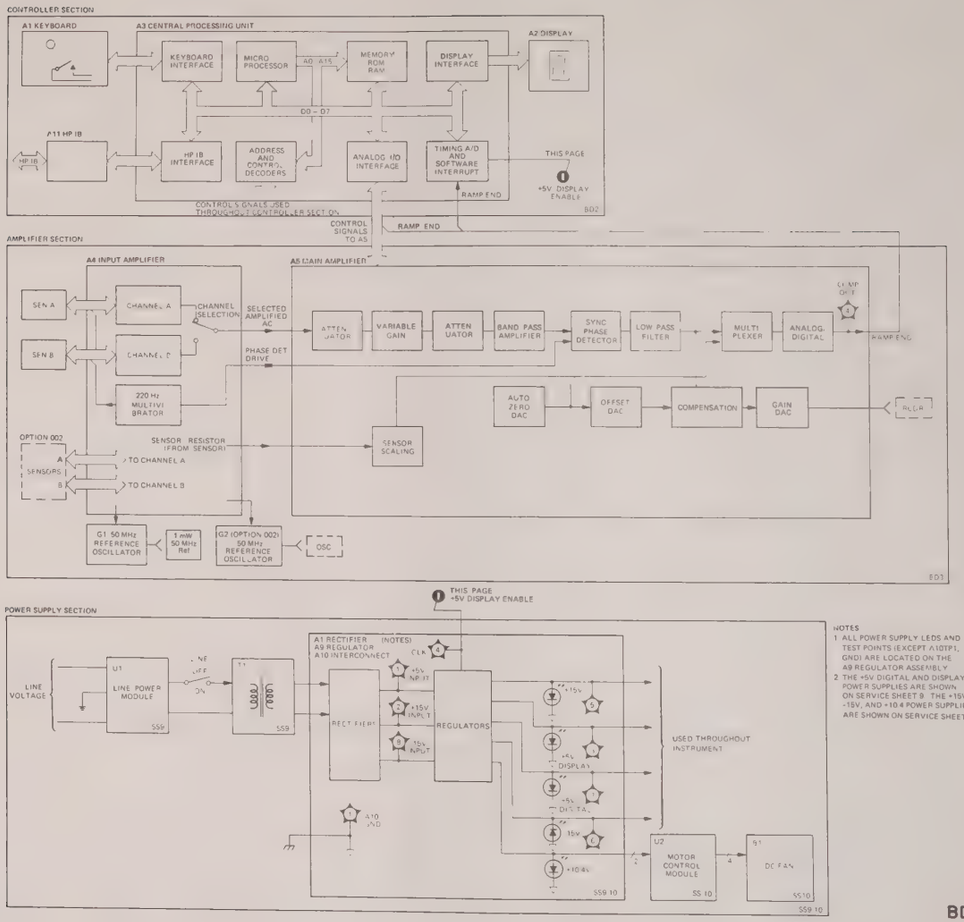


Figure 8-5. Simplified Power Supply Grounding


CONTROLLER SECTION
A1 KEYBOARD
A3 CENTRAL PROCESSING UNIT
A2 DISPLAY
KEYBOARD INTERFACE
MICRO PROCESSOR
MEMORY ROM RAM
DISPLAY INTERFACE
A0 - A15
D0 - D7
A11 HP IB
HP IB
HP IB INTERFACE
ADDRESS AND CONTROL DECODERS
ANALOG I/O INTERFACE
TIMING A/D AND SOFTWARE INTERRUPT
THIS PAGE
+5V DISPLAY ENABLE
RAMP END
CONTROL SIGNALS USED THROUGHOUT CONTROLLER SECTION
CONTROL SIGNALS TO A5
RAMP END
BD2
AMPLIFIER SECTION
A4 INPUT AMPLIFIER
A5 MAIN AMPLIFIER
SEN A
SEN B
CHANNEL A
CHANNEL B
CHANNEL SELECTION
SELECTED AMPLIFIED AC
PHASE DET DRIVE
220 Hz MULTIVIBRATOR
ATTEN UATOR
VARIABLE GAIN
ATTEN UATOR
BAND PASS AMPLIFIER
SYNC PHASE DETECTOR
LOW PASS FILTER
MULTI PLEXER
ANALOG DIGITAL
CLAMP OFF
RAMP END
AUTO ZERO DAC
OFFSET DAC
COMPENSATION
GAIN DAC
REAR
SENSOR SCALING
OPTION 002
A SENSORS B
SENSOR RESISTOR FROM SENSOR
TO CHANNEL A
TO CHANNEL B
G1 50 MHz REFERENCE OSCILLATOR
1 mW 50 MHz Ref
G2 (OPTION 002) 50 MHz REFERENCE OSCILLATOR
OSC
BD3
THIS PAGE +5V DISPLAY ENABLE
POWER SUPPLY SECTION
LINE VOLTAGE
U1
LINE POWER MODULE
556
LINE OFF ON
T1
LOAD
LOAD
559
A1 RECTIFIER (NOTES) A9 REGULATOR A10 INTERCONNECT
RECT FIERS
+5V NP 17
+15V INPUT
-15V INPUT
REGULATORS
CLK
+15V
+5V DISPLAY
-5V DIGITAL
-15V
+10.4V
-10 VD
559 10
USED THROUGHOUT INSTRUMENT
U2
MOTOR CONTROL MODULE
55 10
B1
DC FAN
5510
559 10
NOTES
1 ALL POWER SUPPLY LEDS AND TEST POINTS (EXCEPT A10TP1, GND) ARE LOCATED ON THE A9 REGULATOR ASSEMBLY
2 THE +5V DIGITAL AND DISPLAY POWER SUPPLIES ARE SHOWN ON SERVICE SHEET 9 THE +15V, -15V, AND +10.4 POWER SUPPLIES ARE SHOWN ON SERVICE SHEET 10

BD1

PRINCIPLES OF OPERATION

General

As shown on Service Sheet BD2 Figure 8-7 Controller Section the A3 Central Processing Unit (CPU) is the major functional component of the controller. To better understand and troubleshoot the controller, it can be divided into the following five functional sections:

1. The data input/output circuits (Service Sheet 1). These circuits consist of the A1 Keyboard Assembly, the A11 HP-IB Interface Assembly, and part of the A3 CPU Assembly.

2. The microprocessor and memory circuits (Service Sheet 2). These circuits are all contained on the A3 CPU.

3. The timer and peripheral interface adapter (PIA) circuits (Service Sheet 3). These circuits are all contained on the A3 CPU.

4. The display drivers (Service Sheet 4). These circuits are all contained on the A3 CPU.

5. The front panel display circuits (Service Sheet 5). These circuits are all contained in the A2 Display Assembly.

The CPU controls the rest of the instrument by using the following three buses to enable, address, and transfer data to the other sections of the instrument:

1. The control bus is derived from part of the address bus and hardware generated signals such as power fail or free run. These signals are used to enable specific digital circuits when they are required to perform their designated functions.

2. The address bus controls access to the ROM and RAM. It also supplies inputs to the control decode circuits.

3. The data bus transfers information throughout the controller. Note that the data bus is buffered at the data inputs to the microprocessor, at the ROM and RAM outputs, at the HP-IB circuits and at the I/O interface. These buffers provide the required signal strength to drive the associated circuits. They also help to isolate problems and aid in locating a malfunction when one occurs.

Data Input/Output Section

The A1 Keyboard Assembly is used during local operation to select the measurement configuration of the Power Meter. When a key is pressed, the keyboard priority encoder in the CPU encodes and stores this information in the cathode data display and keyboard scan PIA. When the PIA is enabled, this information is transferred to the microprocessor and the appropriate changes to the instrument are initiated.

The A11 HP-IB Assembly is used during remote operation to interface the HP-IB to the HP-IB interface management and transceiver circuits on the CPU. These circuits manage the exchange of the bi-directional information between the CPU and the HP-IB.

The HP-IB assembly also contains the manual HP-IB address switch. The output from this switch is applied to the HP-IB address buffer on the CPU. Note that the preset HP-IB address that is selected on the switch is only read by the CPU if the current HP-IB address stored in RAM is lost.

Microprocessor and Memory Circuits

The microprocessor and memory circuits with their associated busses form the kernal of the CPU. The microprocessor reads the permanently stored programs in the ROM and uses these instructions to control the operation of the Power Meter. During troubleshooting this kernal can be isolated and exercised by grounding A3TP4 FREE RUN prior to applying power. The clock and timer interrupt circuits provide the synchronization required for correct operation of the CPU.

The address and control decode circuits derive the digital control signals from part of the address bus and hardware monitoring inputs. This process is described in detail on Service Sheet 2. These control signals are used to enable different digital circuits when required by the microprocessor.

The RAM is used for temporary data storage while the Power Meter is operating. However, combined with the reset power fail, RAM chip enable, and the battery circuits, part of the RAM is used to store data when the Power Meter is turned off. The following information is retained when power is turned off:

1. The current front panel setup.

2. Any other front panel setup that has been saved using the STORE key, or the HP-IB program code ST.

3. The current zeroing and calibration data. Additional information on the zeroing and calibration software routines is contained in Service Sheet 3.

When power is applied to the instrument it goes through its pretest routine and the restart power fail resets the CPU to a predetermined hardware configuration. The CPU then retrieves the last front panel setup stored in RAM and establishes the required measurement configuration. This controlled restart ensures that the Power Meter always starts operation from a known configuration.

When power is turned off (or lost), the combined action of the reset power fail and RAM chip enable circuits protect the data stored in the RAM. This is accomplished by immediately disabling the input/output functions of the RAM and applying the battery voltage to the Vcc input of the portion of RAM used for data storage when power is off. The reason the input/output functions are disabled is to prevent any false data from being stored while the power level is dropping. The required restart data is always present in RAM.

The service function switch and buffer can select and initiate diagnostic programs that are used when troubleshooting the Power Meter. A list of the available diagnostic programs and instructions on how to run them are contained in the troubleshooting section of this service sheet.

Timer A/D, PIA, and Latch Circuits

The two main purposes of the timer A/D circuit are to time the A/D conversion in the A5 Main Amplifier Assembly and supply the 1 ms software interrupt to the timer interrupt latch. The 4 MHz input clocks the timer A/D circuit. The start ramp signal starts the internal counter at the same time as the ramp generator in the main amplifier is started. When the measured input signal and the ramp generator output are equal, the ramp end signal from the main amplifier stops the counter. The counter output is read to the microprocessor under software control. The microprocessor uses this data to perform the required computations and displays the results on the front panel A2 Display Assembly.

The analog I/O PIA applies the required measurement configuration control signals to the main amplifier.

The cathode data display and keyboard scan PIA controls the addressable data display latch circuit and the inputs and outputs to the A1 Keyboard Assembly. The addressable data display latch circuit controls the cathode data display drivers.

The LED data latch is enabled by the anode data display and LED address decode circuit and controlled directly by the microprocessor. The LED lighting patterns are used to obtain circuit information when troubleshooing the instrument. Additional information on how to use the LED information is contained in the troubleshooting section of this service sheet.

The anode data display and LED address decode circuit also selectively enables one of the anode data display latches.

Display Drivers

The anode and cathode display drivers are used to refresh the front panel display. The sequence of the drivers is controlled by the CPU through the anode data display latches and addressable data display latch and drivers (Service Sheet 3).

Display Assembly

The A2 Display Assembly displays the current instrument configuration and the appropriate measurement result or error message.

PRINCIPLES OF OPERATION

General

As shown on Service Sheet BD3 Figure 8-12 Amplifier Section the A4 Input Amplifier Assembly and the A5 Main Amplifier Assembly are the major functional components. To better understand and troubleshoot the Amplifier Section, it can be divided into the following five functional sections:

1. The connected power sensor (refer to the applicable Power Sensor Operating and Service Manual).

2. The input amplifier circuits (Service Sheet 6). These circuits are on the A4 Input Amplifier Assembly.

3. The digital I/O and DAC circuits (Service Sheet 7). These circuits are all contained on the A5 Main Amplifier Assembly.

4. The amplifier, detector, and comparartor circuits (Service Sheet 8). These circuits are all contained on the A5 Main Amplifier Assembly.

5. The 1 mW 50 MHz Power Reference circuits (Service Sheet 11)

Connected Power Sensor and Input Amplifier Circuits

The connected power sensors determine the frequency range, dynamic range, and measurement accuracy of the combined power sensors and Power Meter. A simplified block diagram of the interconnection between the power sensors, the two channels of the input amplifier, and the monitoring circuits in the main amplifier is shown in Figure 8-8. The basic operation of these circuits is described in the following paragraphs.

The power sensor dissipates the RF input power into a 50 Ohm termination and generates a dc voltage proportional to the RF input power level.

The 220 Hz multivibrator provides the 220 Hz drive signals to the power sensors to switch the dc voltage. The resulting output is a 220 Hz signal that is proportional in amplitude to the RF input power level and is in phase with the 220 Hz reference signal that is applied to the synchronous phase detector in the main amplifier.

The shaper feedback circuit serves to reduce the gain of the power sensor and the input amplifier at higher power levels. This

reduction in gain is required to offset the improved efficiency of the power sensing elements at the higher power levels.

The sensor resistor input to the sensor resistor selection circuit in the main amplifier is used by the controller to determine which model power sensor is connected to an input channel. Note that any two of the different model power sensors can be connected to the Power Meter. The controller is able to adjust the individual channel inputs to the connected power sensor and provide the correct measurement result for each channel. If the Option 002 rear panel input ports are present, the controller can determine if more than one power sensor is connected to the same channel input. For example, if power sensors are connected to both the front panel and rear panel A inputs, error message 33 "2 inPutS" is displayed.

The output from the auto zero DAC on the main amplifier is set by the controller and in conjunction with stored values in the software is used to remove any dc offset voltage associated with the individual power sensors.

The controller sets the miscellaneous buffer on the main amplifier to connect the following signal paths for the selected input channel:

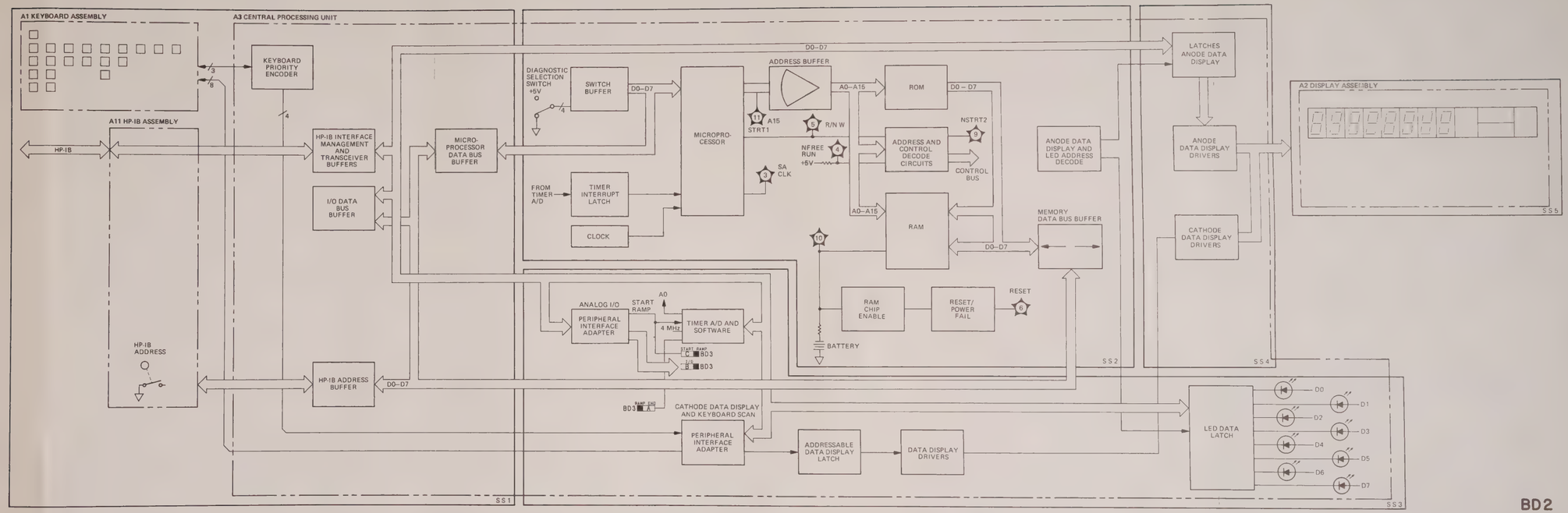
1. The amplified ac output.
2. The sensor resistor input.
3. The sensor ground reference to the A GND circuit on the main amplifier.

The power sensor and A4 Input Amplifier Assembly function together to amplify the modulated 220 Hz signal by a factor of approximately 600.

Digital I/O and DAC Circuits

The digital I/O circuits interpret the control signals from the CPU and set the input amplifier and the main amplifier to the correct configuration to perform the required measurement. The outputs from the digital I/O circuits are stored in the flip-flop registers of the miscellaneous buffer, the zero DAC buffer, and the gain/attenuator buffer.

Figure 8-9 is a simplifed block diagram of the zeroing loop. When the ZERO key is pressed, or the HP-IB program code ZE is given, the software zeroing routine is initiated. The auto zeroing DAC output is used to zero the input from the power sensor with no RF signal applied. The DAC output is applied to the power sensor, is chopped in the sensor then the output from the sensor goes through the entire Power Meter amplifier chain.


A1 KEYBOARD ASSEMBLY
A3 CENTRAL PROCESSING UNIT
A11 HP-IB ASSEMBLY
KEYBOARD PRIORITY ENCODER
HP-IB
HP-IB INTERFACE MANAGEMENT AND TRANSCEIVER BUFFERS
I/O DATA BUS BUFFER
MICRO-PROCESSOR DATA BUS BUFFER
HP-IB ADDRESS
HP-IB ADDRESS BUFFER
D0–D7
DIAGNOSTIC SELECTION SWITCH
+5V
SWITCH BUFFER
FROM TIMER A/D
TIMER INTERRUPT LATCH
CLOCK
MICRO-PROCESSOR
ADDRESS BUFFER
A15
STRT1
R/N W
NFREE RUN
+5V
SA CLK
A0–A15
ROM
ADDRESS AND CONTROL DECODE CIRCUITS
NSTRT2
CONTROL BUS
RAM
ANODE DATA DISPLAY AND LED ADDRESS DECODE
MEMORY DATA BUS BUFFER
ANALOG I/O
PERIPHERAL INTERFACE ADAPTER
START RAMP
A0
4 MHz
TIMER A/D AND SOFTWARE
BD3
BATTERY
RAM CHIP ENABLE
RESET/ POWER FAIL
RESET
CATHODE DATA DISPLAY AND KEYBOARD SCAN
PERIPHERAL INTERFACE ADAPTER
ADDRESSABLE DATA DISPLAY LATCH
DATA DISPLAY DRIVERS
LATCHES ANODE DATA DISPLAY
ANODE DATA DISPLAY DRIVERS
CATHODE DATA DISPLAY DRIVERS
A2 DISPLAY ASSEMBLY
LED DATA LATCH
D0
D1
D2
D3
D4
D5
D6
D7
SS1
SS2
SS3
SS4
SS5

BD2

The CPU sets the output of the DAC to get the output from the low pass filter (Service Sheet 8) as close to zero as possible. The remaining offset is computed and stored as a series of 10 values for all combinations of the slow and fast filters and the 5 ranges. These values in conjunction with the computed DAC setting are used to determine the zero level for all input signals until the meter is zeroed again.

The stable current source supplies reference current for the zeroing DAC and the offset removal DAC.

The offset removal DAC is controlled by the CPU and subtracts the offsets introduced by the amplifier chain. The output of the DAC is summed with the output from the amplifier chain. The resulting signal is buffered and supplies the reference current for the gain DAC. This circuit is the hardware equivalent of the 10 computed values used by the CPU to determine the correct zeroing adjustments for the measurement that is being made.

The gain DAC is controlled by the CPU and divides the reference signal by the gain of the variable gain amplifier (Service Sheet 8). The gain setting of the variable gain amplifier is determined by the last calibration performed. The output of the DAC is buffered and applied to the rear panel RCDR (recorder) output.

Amplifier, Detector, Filter, and Comparator Circuits

The settings of the two range attenuators and the variable gain amplifier are controlled by the CPU through the gain/attenuator buffer. The range attenuators are set to match the front panel selected range if in MNL RANGE mode or the CPU selected range if in AUTO RANGE mode. The variable gain amplifier is set to provide an output from the low pass filter between 3.02 and 3.63 Vdc. The setting required is determined during calibration (CAL ADJ). Calibration is described later.

The bandpass amplifiers consist of several active stages and RC networks. The bandpass response peaks at 230 Hz with 0 degrees of phase shift.

The synchronous phase detector rectifies the output from the bandpass amplifier by multiplying the input by + or -- 1. Thus, the output of the detector is a signal whose filtered dc value is proportional to the true amplitude of the 220 Hz input signal.

The low pass filter consists of a slow filter and a fast filter. The input from the detector is applied to both. The CPU selects the output of the required filter. Which low pass filter output is selected is determined by which digital filter is selected. It is important to understand that the digital filter is not a

circuit. It is an averaging function that is performed by the software and controlled by the front panel AUTO FILTER and MNL FILTER keys. The selection of the slow and fast filters is determined as follows:

1. If the digital filter number is 0, 1, or 2, the fast low pass filter (45 ms) is selected.

2. If the digital filter number is 3 through 9, the slow low pass filter (800 ms) is selected.

A detailed description of digital filtering is provided later on this service sheet. The output of the low pass filter is buffered and applied to the following two circuits:

1. The summing point of the offset removal DAC (Service Sheet 7). The use of this output was described previously.

2. The Analog/Digital Input Multiplexer.

The Analog/Digital Multiplexer can select any one of the following signals as the ADC input to the comparator:

1. The low pass filter output.

2. The front and or rear sensor resistors for sensors connected to channels A or B.

3. The B GND (0V).

4. The auto zero DAC output (this signal is only selected for testing).

5. The offset removal DAC output (this signal is selected during the zeroing routine).

6. The gain DAC output (this signal is only selected during the calibration routine).

The Analog-to-Digital Converter (ADC) in the Power Meter consists of the following three parts:

1. The ramp generator and comparator circuits in the main amplifier.

2. The timer A/D and software interrupt circuit in the CPU.

3. The software routine that controls these circuits.

Figure 8-10 Simplified A/D Converter Block Diagram shows the relationship between the CPU and the main amplifier circuits. The method of digitizing the input signal is identical for all input signals. The sequence is as follows:

1. The selected signal from the analog/digital input multiplexer is applied to the ADC input of the comparator.

2. The CPU generates the start ramp signal. This signal is applied simultaneously to the timer A/D in the CPU and the ramp generator in the main amplifier.

3. The timer A/D starts counting at a 4 MHz rate.

4. Using the 2.5V reference input, the ramp generator produces a linear positive ramp.

5. When the ramp voltage equals the ADC input voltage, the comparator sends the ramp end signal to the timer A/D circuit in the CPU. The counter is stopped at the count that represents the value of the ADC input signal. This information is used by the microprocessor to compute the measurement value. This value can then be used in any other computations required to obtain the final displayed information.

1 mW 50 MHz Power Reference Circuit

The G1 50 MHz Reference Oscillator provides a 50 +/- 5 MHz output at 1 mW +/- 0.7%. This output is used during operation to calibrate the individual power sensors used with the Power Meter. It can also be used during the Operator's Check and troubleshooting procedures as a signal source.

As explained previously, the zeroing software routine determines the setting for the auto zero DAC, calulates and stores 10 offset values for the 10 combinations of the two low pass filters and the five available ranges. For correct calibration, the connected power sensor and the Power Meter must be zeroed prior to calibration.

The main functions of the power sensor calibration software routine are as follows:

1. Verify an appropriate power source and a power sensor are connected to the Power Meter. In some cases, the power source is the Power Meter's 1 mW 50 MHz Reference output.

2. Set the range attenuators and the low pass and digital filters to the correct settings for the connected power sensor.

3. Set the variable gain amplifier so that the ADC output reads between 3.02 and 3.63 Vdc.

4. Calculate and scale the 10 zeroing offset values to provide more accurate power measurements.

5. Calculate the offset DAC settings to match these new values.

6. Find the gain DAC settings required to provide a full scale 1 Vdc output at the rear panel RCDR (recorder) connector.

After the power sensor and Power Meter are correctly zeroed and calibrated, they can be used to make power measurements within the specified parameters of the combined instruments.

Digital Filter Software Routine (Digital Filter)

The most important point to understand about the digital filter is that it is a software routine and not a hardware component. It does, however, have a direct bearing on the selection of the slow or fast low pass filter. The selected combination of these two filters determine the speed, resolution, and stability (jitter) of the final measurement result.

The digital filter is an averaging filter. The value returned by the digital filter is the average of the last N power readings, where N is the filter length. The filter length is determined by two being raised to some power where that power is the filter range number zero through nine. The filter number can be manually selected using the front panel MNL FILTER key or automatically selected by the software if the AUTO FILTER key is active. The relationship between the selected filter number and the filter length is as follows:

FILTER NUMBER	FILTER LENGTH (Number of Readings)
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512

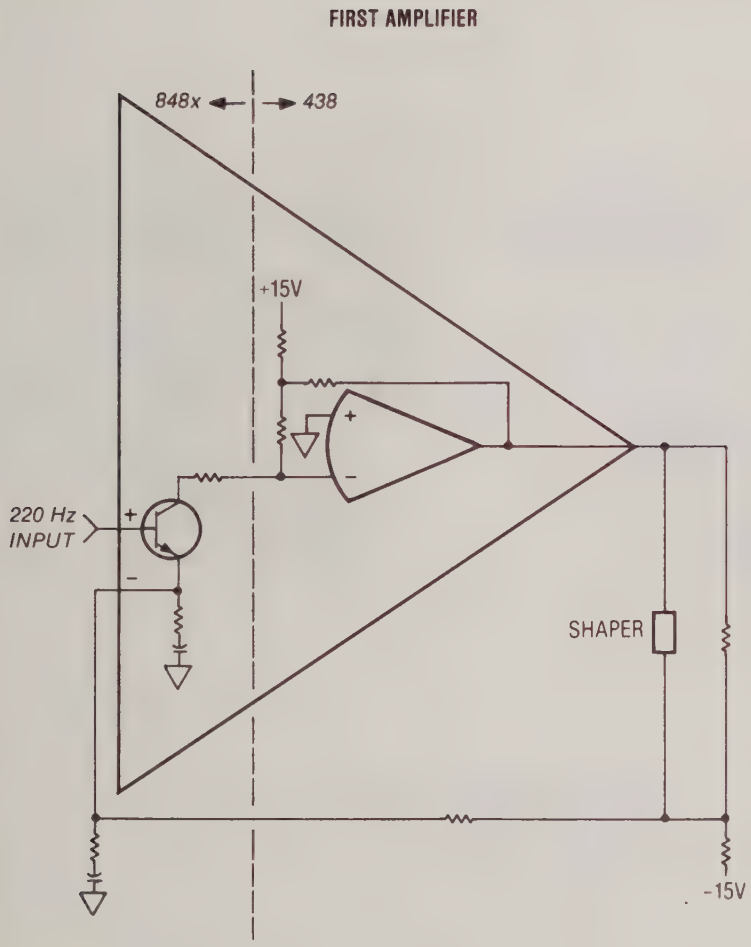


Figure 8-8. Simplified Power Sensor and Input Amplifier Diagram

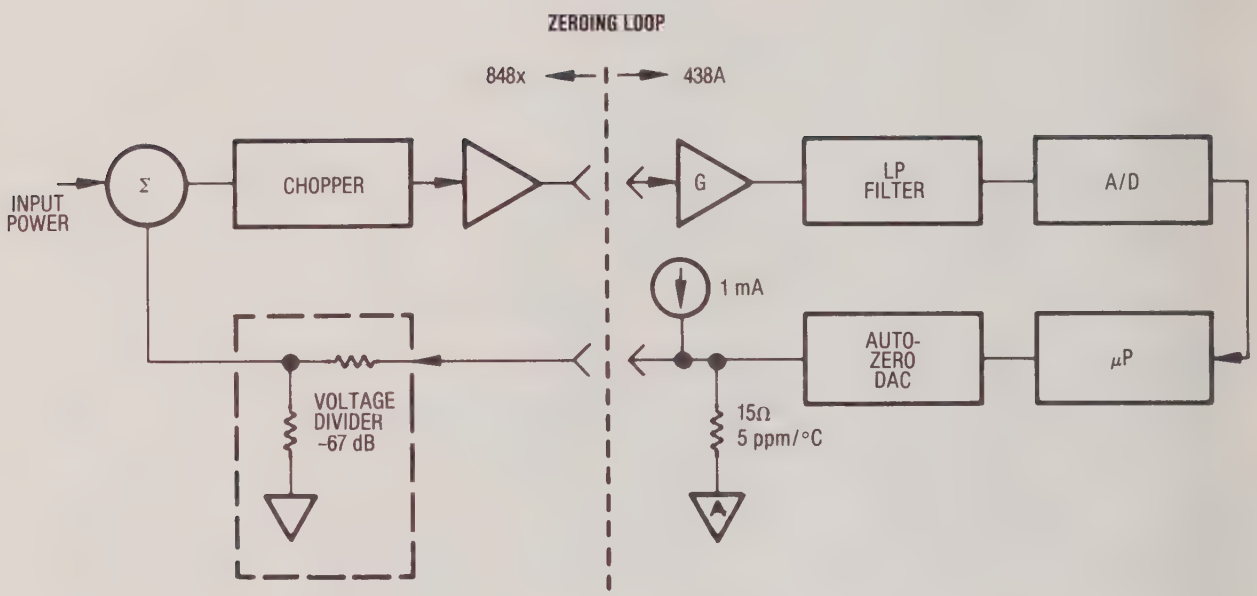


Figure 8-9. Simplified Zeroing Block Diagram

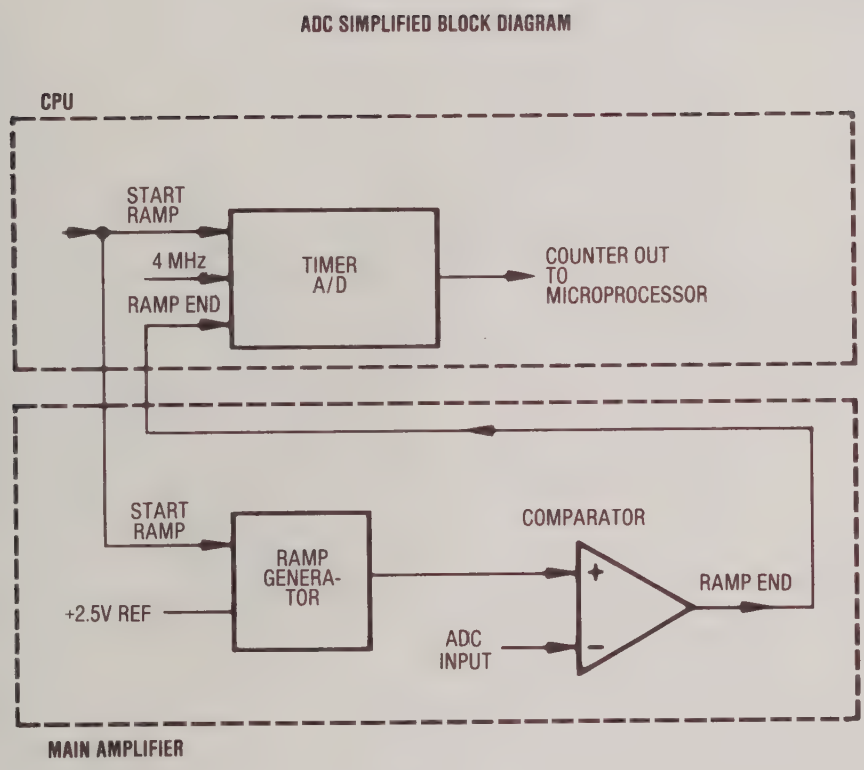
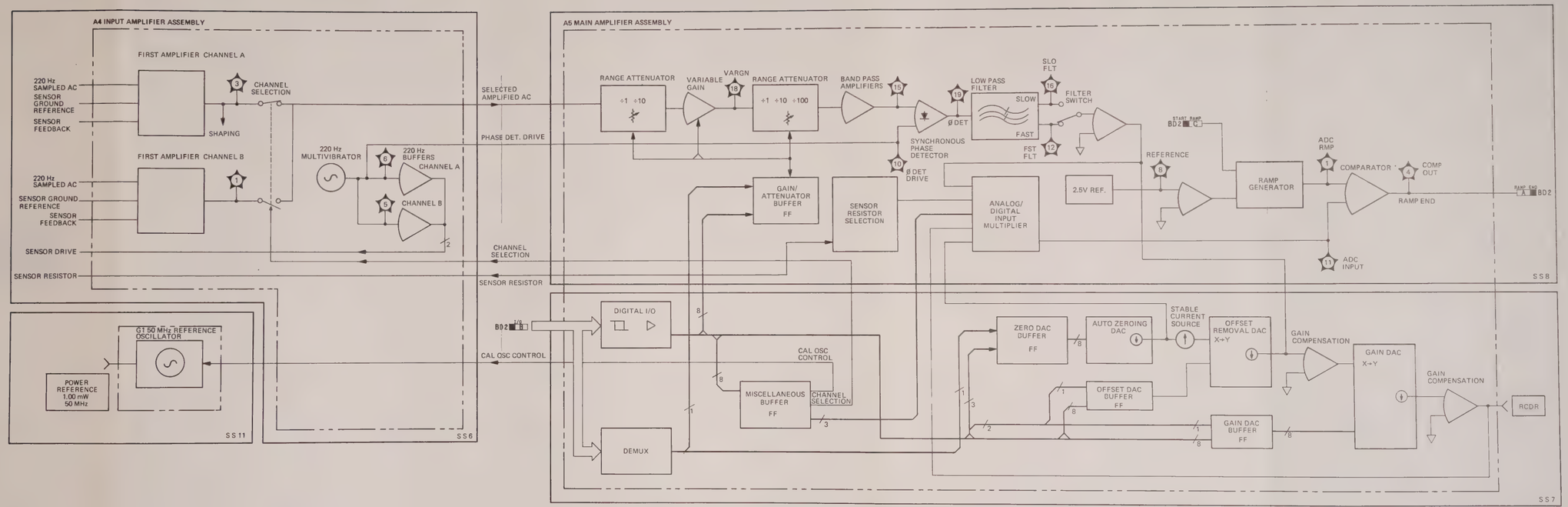
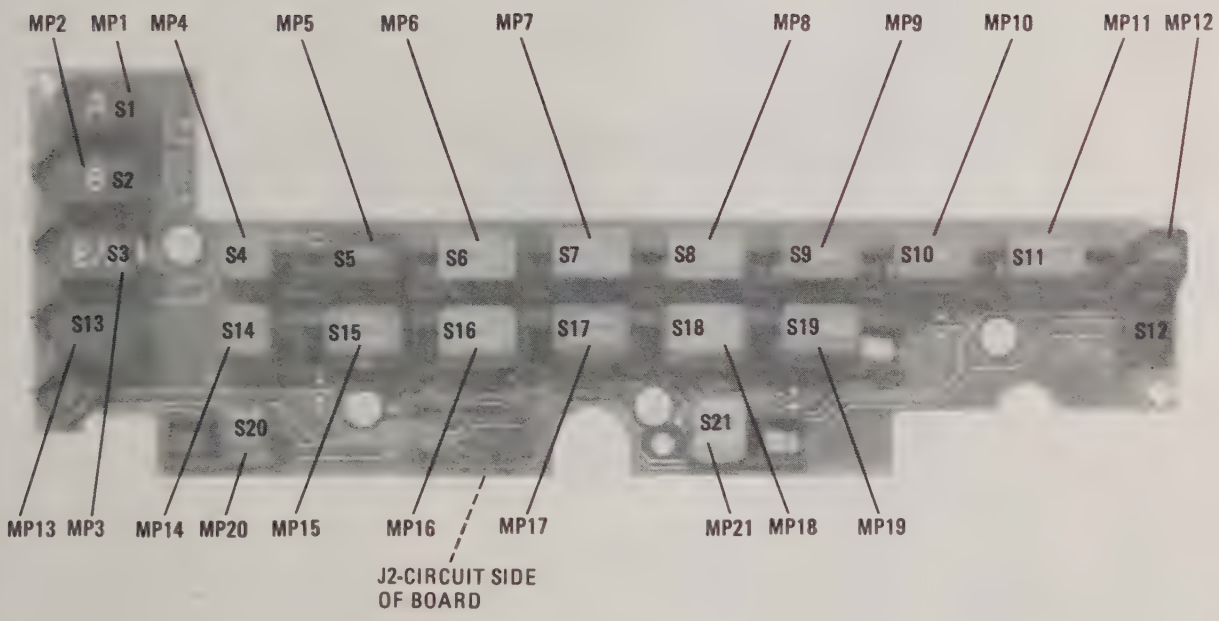


Figure 8-10. Simplified Analog to Digital (A/D) Converter Block Diagram

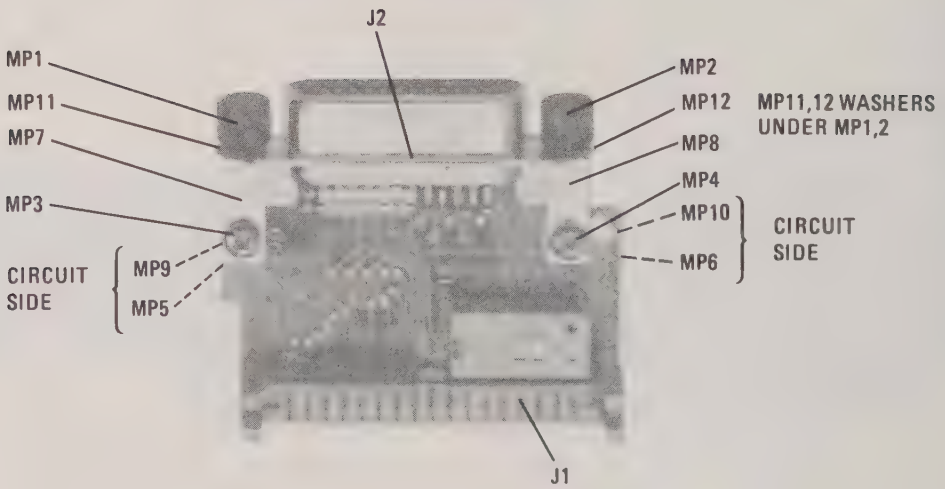

A4 INPUT AMPLIFIER ASSEMBLY
FIRST AMPLIFIER CHANNEL A
220 Hz SAMPLED AC
SENSOR GROUND REFERENCE
SENSOR FEEDBACK
CHANNEL SELECTION
SHAPING
FIRST AMPLIFIER CHANNEL B
220 Hz SAMPLED AC
SENSOR GROUND REFERENCE
SENSOR FEEDBACK
220 Hz MULTIVIBRATOR
220 Hz BUFFERS
CHANNEL A
CHANNEL B
SENSOR DRIVE
SENSOR RESISTOR
SELECTED AMPLIFIED AC
PHASE DET. DRIVE
CHANNEL SELECTION
SENSOR RESISTOR
G1 50 MHz REFERENCE OSCILLATOR
POWER REFERENCE 1.00 mW 50 MHz
SS 11
SS 6
CAL OSC CONTROL
A5 MAIN AMPLIFIER ASSEMBLY
RANGE ATTENUATOR
÷1 ÷10
VARIABLE GAIN
VARGN
RANGE ATTENUATOR
÷1 ÷10 ÷100
BAND PASS AMPLIFIERS
SYNCHRONOUS PHASE DETECTOR
ø DET
ø DET DRIVE
LOW PASS FILTER
SLOW
FAST
SLO FLT
FST FLT
FILTER SWITCH
GAIN/ ATTENUATOR BUFFER FF
SENSOR RESISTOR SELECTION
ANALOG/ DIGITAL INPUT MULTIPLIER
2.5V REF.
REFERENCE
START RAMP
RAMP GENERATOR
ADC RMP
COMPARATOR
COMP OUT
RAMP END
ADC INPUT
SS 8
DIGITAL I/O
DEMUX
CAL OSC CONTROL
MISCELLANEOUS BUFFER FF
CHANNEL SELECTION
ZERO DAC BUFFER FF
AUTO ZEROING DAC
STABLE CURRENT SOURCE
OFFSET REMOVAL DAC X→Y
GAIN COMPENSATION
OFFSET DAC BUFFER FF
GAIN DAC X→Y
GAIN DAC BUFFER FF
GAIN COMPENSATION
RCDR
SS 7

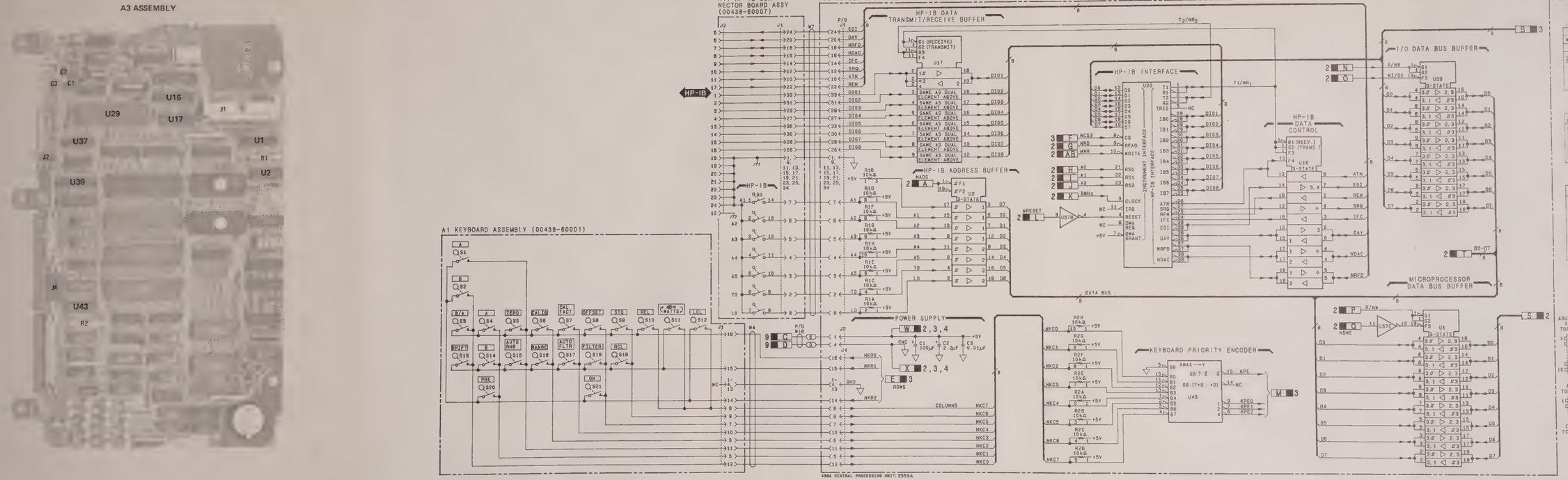
BD3

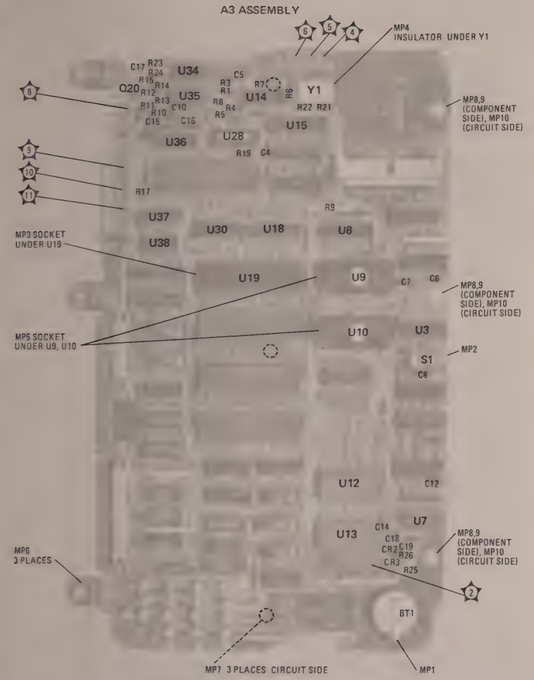
A1 ASSEMBLY


MP2
MP1
MP4
MP5
MP6
MP7
MP8
MP9
MP10
MP11
MP12
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
S14
S15
S16
S17
S18
S19
S20
S21
MP13
MP3
MP14
MP20
MP15
MP16
MP17
MP21
MP18
MP19
J2-CIRCUIT SIDE
OF BOARD

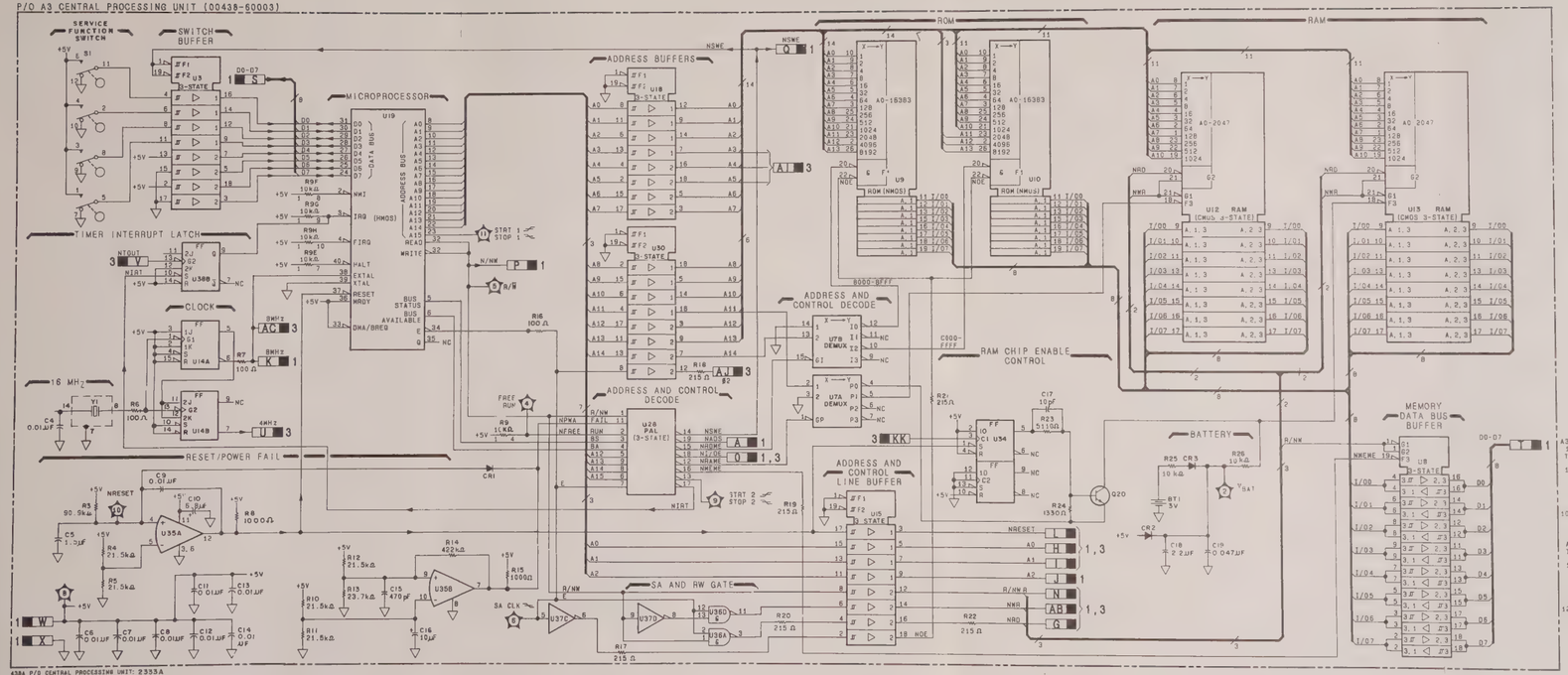
A11 ASSEMBLY




A3 ASSEMBLY
A11 HP-IB CONNECTOR BOARD ASSY (00438-60007)
P/O A3 CENTRAL PROCESSING UNIT (00438-60003)
HP-IB DATA TRANSMIT/RECEIVE BUFFER
HP-IB INTERFACE
HP-IB DATA CONTROL
I/O DATA BUS BUFFER
MICROPROCESSOR DATA BUS BUFFER
HP-IB ADDRESS BUFFER
POWER SUPPLY
KEYBOARD PRIORITY ENCODER
DATA BUS
A1 KEYBOARD ASSEMBLY (00438-60001)
HP-IB
NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
REFERENCE DESIGNATIONS
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
INTEGRATED CIRCUIT +5-VOLT AND GROUND CONNECTIONS
LOGIC LEVELS
CIRCUIT BOARD TOP VIEW
A1, A11, P/O A3
8-47/8-48



P/O A3 CENTRAL PROCESSING UNIT (00438-60003)



NOTES
1. REFER TO TABLE 8-5 FOR SCHEMATIC DIAGRAM NOTES

REFERENCE DESIGNATIONS

A3	A3 CONT.
BT1	TP2,4-6,8-11
C6-19	U3,7-10,12-15,
C24-3	16, 28, 30,
MP1-10	34-38
R5-26	
S1	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q20	1854-0477
U3, 15, 18, 30	1820-2024
U7	1820-1281
U8	1820-2075
U9	00438-80002
U10	00438-80003
U12, 13	1818-1788
U14, 38	1820-1212
U19	1820-2624
U28	00438-80001
U34	1820-1753
U35	1826-0175
U36	1820-1197
U37	1820-1199

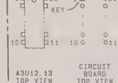
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER	
U3, 8, 15, 18, 28, 30	+5V	20
		10
U7, 14, 38	+5V	16
		8
U9, 10	+5V	1, 28
		14
U12	+5V	24
		12
U13	+5V (F)	24
		12
U19	+5V	7
		1
U34, 36, 37	+5V	14
		7

LOGIC LEVELS

	TTL	CMOS
HIGH	+2V	>3.5V
LOW	+0.8V	<1.5V
- TO MORE NEG THAN		
+ TO MORE POS THAN		
OPEN	HIGH	UNDEF
GROUND	LOW	LOW

A3U3, 8, 15, 18, 28, 30 CIRCUIT BOARD TOP VIEW



A3U7, 14, 38 CIRCUIT BOARD TOP VIEW

A3U9, 10 CIRCUIT BOARD TOP VIEW

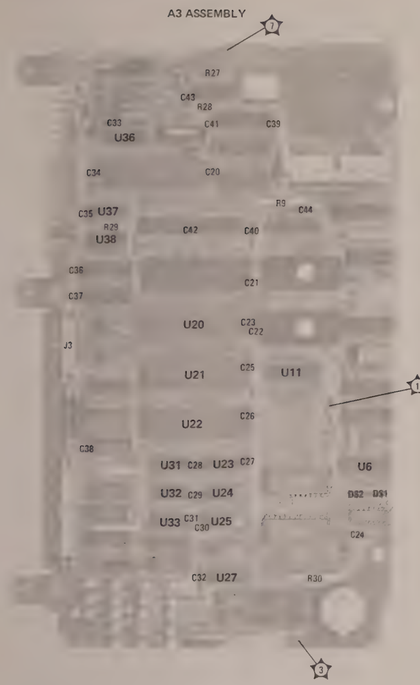
A3U12, 13 CIRCUIT BOARD TOP VIEW

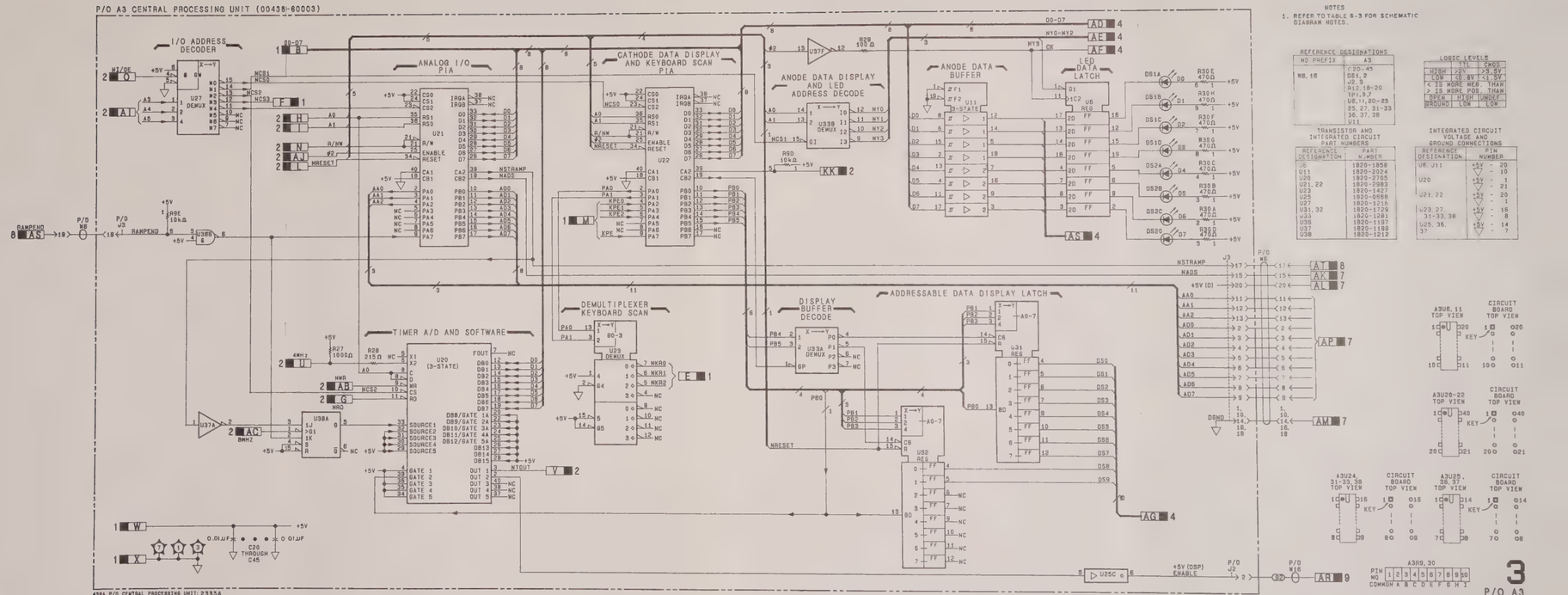
A3U34, 36, 37 CIRCUIT BOARD TOP VIEW

A3U19 CIRCUIT BOARD TOP VIEW

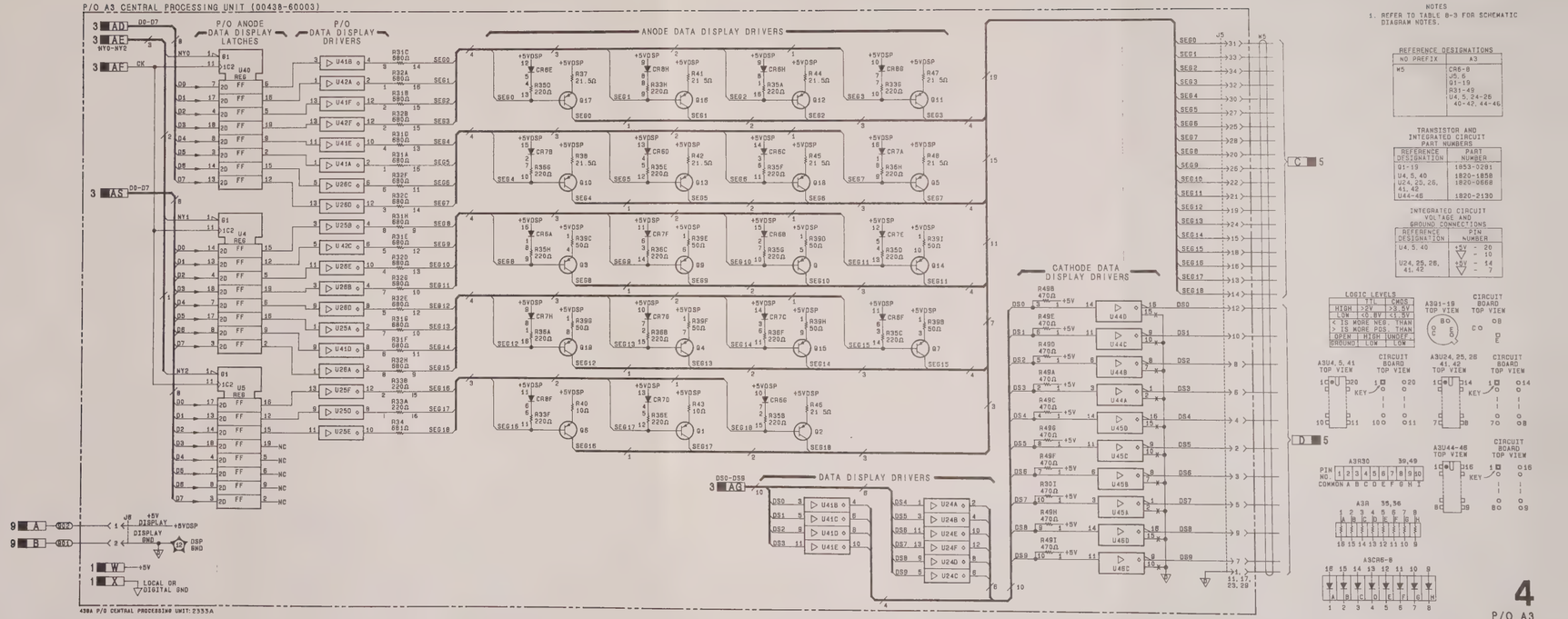
A3P9

PIN NO.	1	2	3	4	5	6	7	8	9	10
COMMON	A	B	C	D	E	F	G	H	I	


A3 ASSEMBLY
1
2
R27
C43
R28
C33
C41
C39
U36
C34
C20
R9
C44
C35
U37
R29
C42
C40
U38
C36
C21
C37
U20
C23
C22
J3
U21
C25
U11
C26
U22
C38
U31
C28
U23
C27
U6
U32
C29
U24
DS2
DS1
U33
C31
U25
C30
C24
C32
U27
R30


P/O A3 CENTRAL PROCESSING UNIT (00438-60003)
I/O ADDRESS DECODER
ANALOG I/O PIA
CATHODE DATA DISPLAY AND KEYBOARD SCAN PIA
ANODE DATA DISPLAY AND LED ADDRESS DECODE
ANODE DATA BUFFER
LED DATA LATCH
TIMER A/D AND SOFTWARE
DEMULTIPLEXER KEYBOARD SCAN
DISPLAY BUFFER DECODE
ADDRESSABLE DATA DISPLAY LATCH
RAMPEND
NSTRAMP
NMOS
NRESET
NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
REFERENCE DESIGNATIONS
LOGIC LEVELS
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS
A3U5, 11 TOP VIEW
A3U20-22 TOP VIEW
A3U24, 31-33, 38 TOP VIEW
A3U25, 36, 37 TOP VIEW
A3R9, 30
P/O A3
8-51/8-52

A3 ASSEMBLY



NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS	
NO PREFIX	A3
W5	CR6-8 J5,6 Q1-19 R31-49 U4,5,24-26 40-42,44-46

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q1-19	1853-0291
U4,5,40	1820-1858
U24,25,26,41,42	1820-0668
U44-46	1820-2130

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U4,5,40	+5V - 26 GND - 13
U24,25,26,41,42	+5V - 14 GND - 7

LOGIC LEVELS

	TTL	CMOS
HIGH	2.0V	3.5V
LOW	0.8V	1.5V
< IS MORE NEG. THAN		
> IS MORE POS. THAN		
OPEN	HIGH	UNDF.
GROUND	LOW	LOW

A3J1-19 TOP VIEW

CIRCUIT BOARD TOP VIEW

A3U4, 5, 41 TOP VIEW

A3U24, 25, 26 41, 42 TOP VIEW

A3U44-46 TOP VIEW

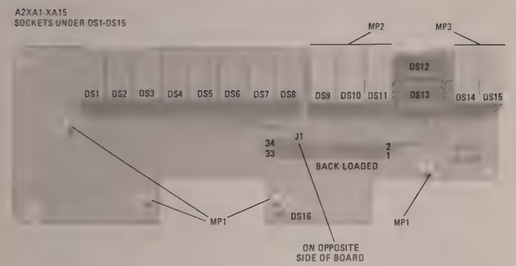
A3R30

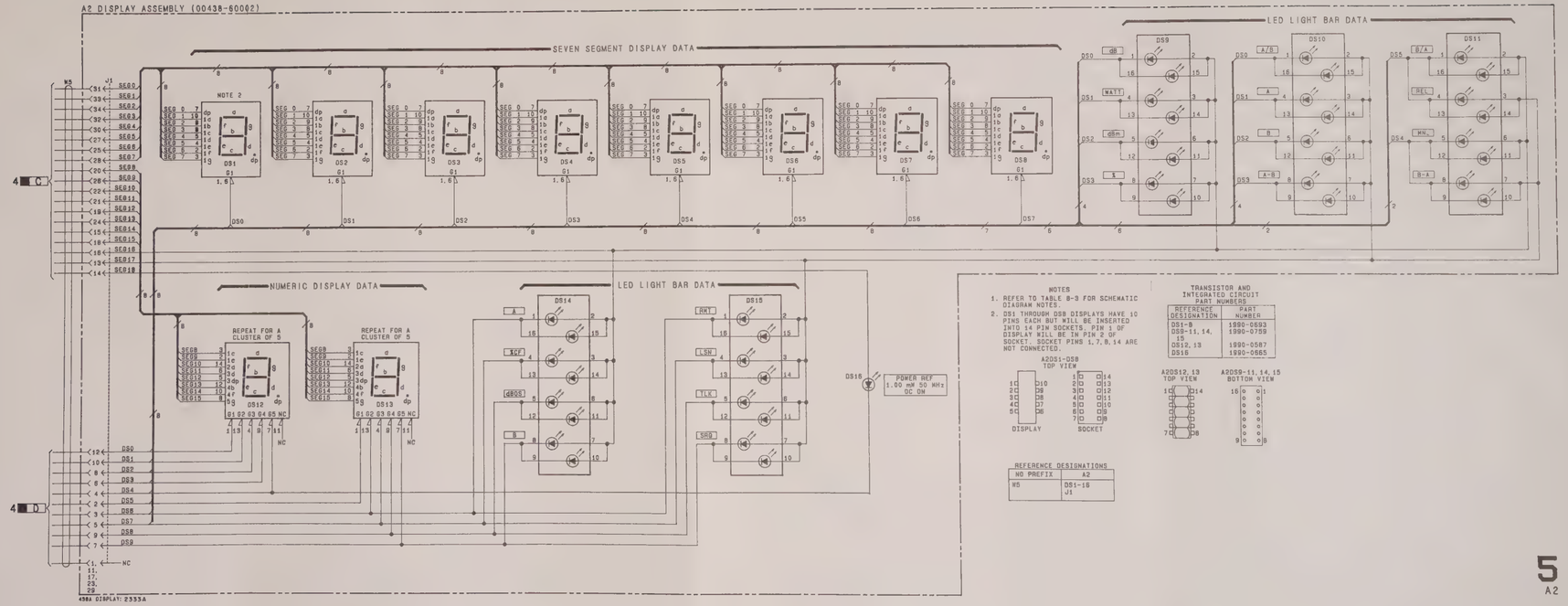
PIN NC COMMON A B C D E F G H I

A3R 35,36

A3CR6-8

A2 ASSEMBLY





NOTES

1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
2. DS1 THROUGH DS8 DISPLAYS HAVE 10 PINS EACH BUT WILL BE INSERTED INTO 14 PIN SOCKETS. PIN 1 OF DISPLAY WILL BE IN PIN 2 OF SOCKET. SOCKET PINS 1, 7, 8, 14 ARE NOT CONNECTED.

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
DS1-8	1990-0593
DS9-11, 14, 15	1990-0759
DS12, 13	1990-0587
DS16	1990-0585

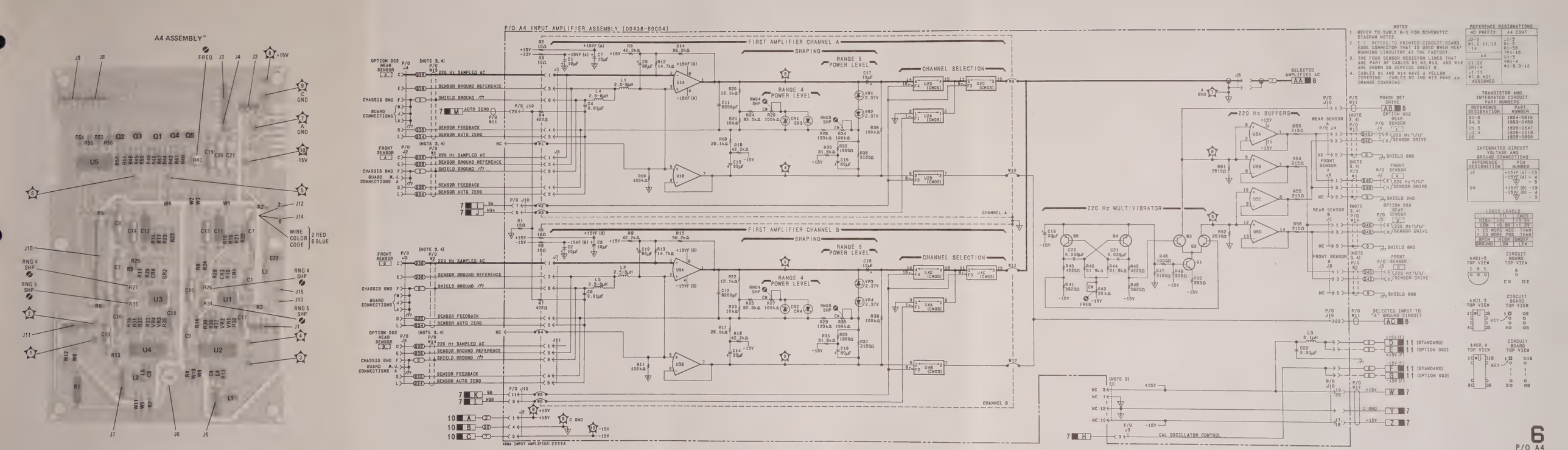
A2DS1-DS8 TOP VIEW

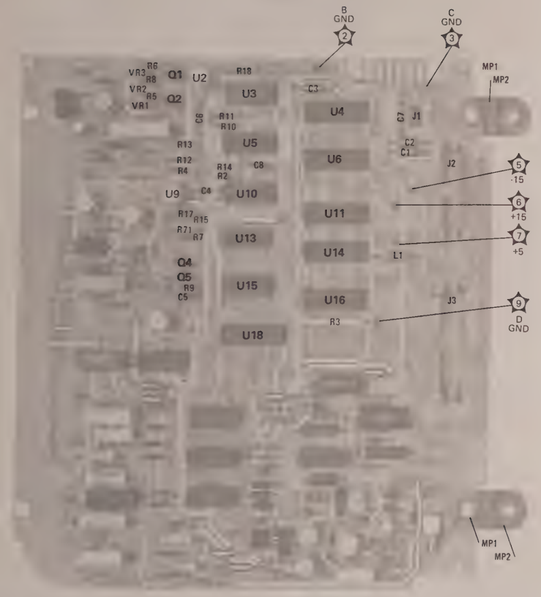
A2DS12, 13 TOP VIEW

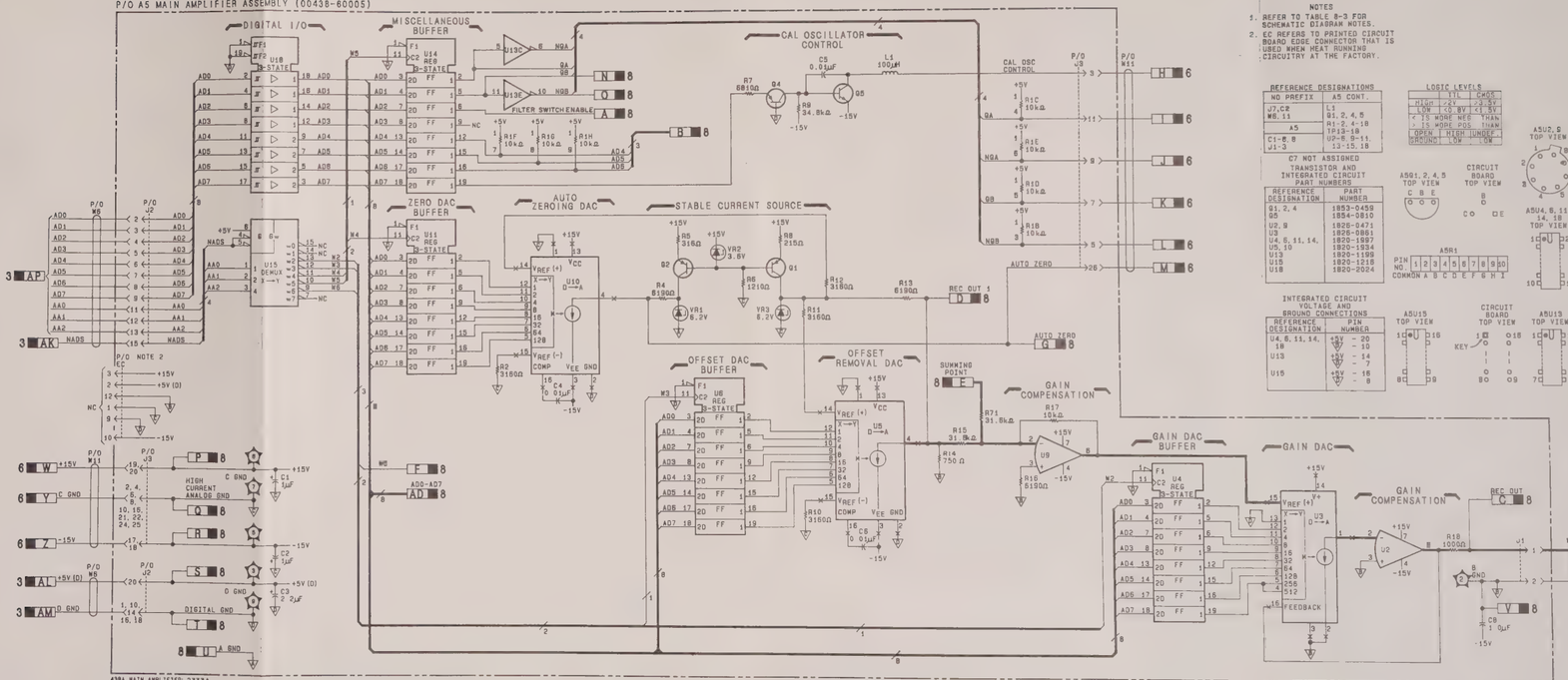
A2DS9-11, 14, 15 BOTTOM VIEW

REFERENCE DESIGNATIONS

NO PREFIX	A2
W5	DS1-16 J1


A4 ASSEMBLY
P/O A4 INPUT AMPLIFIER ASSEMBLY (00438-60004)
FIRST AMPLIFIER CHANNEL A
FIRST AMPLIFIER CHANNEL B
SHAPING
RANGE 5 POWER LEVEL
RANGE 4 POWER LEVEL
CHANNEL SELECTION
CHANNEL A
CHANNEL B
220 Hz BUFFERS
220 Hz MULTIVIBRATOR
OPTION 002 REAR SENSOR
FRONT SENSOR
SELECTED AMPLIFIED AC
PHASE DET DRIVE
SELECTED INPUT TO "A" GROUND CIRCUIT
CAL OSCILLATOR CONTROL
WIRE COLOR CODE
2 RED
6 BLUE
NOTES
1 REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
2 E.C. REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.
3 THE FOUR SENSOR RESISTOR LINES THAT ARE PART OF CABLES W1, W2, W13, AND W14 ARE SHOWN ON SERVICE SHEET 8.
4 CABLES W1 AND W14 HAVE A YELLOW COVERING. CABLES W2 AND W13 HAVE AN ORANGE COVERING.
REFERENCE DESIGNATIONS
NO PREFIX | A4 CONT.
J2-5 | J1-5
W1, 2, 11, 13, 14 | Q1-5
A4 | R1-56
TP1-10
U1-5
C1, 22 | VR1-4
CR1-4 | W3-6, 9-12
J1-11
W7, 8 NOT ASSIGNED
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
REFERENCE DESIGNATION | PART NUMBER
Q1-3 | 1854-0810
Q4, 5 | 1853-0459
U1, 3 | 1826-0547
U2, 4 | 1826-1219
U5 | 1826-0600
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS
REFERENCE DESIGNATION | PIN NUMBER
J2 | +15V (A) -13, -15V (A) -4, -5
U4 | +15V (B) -13, -15V (B) -4, -5
LOGIC LEVELS
 | TTL | CMOS
HIGH | +2V | +3.5V
LOW | +0.8V | +1.5V
< IS MORE NEG. THAN
> IS MORE POS. THAN
OPEN | HIGH | UNDEFINED
GROUND | LOW | 0V
A4U1, 3 TOP VIEW
A4U2, 4 TOP VIEW
CIRCUIT BOARD TOP VIEW
6
P/O A4
8-57/8-58





NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
2. EC REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY.

REFERENCE DESIGNATIONS

NO PREFIX	A5 CONT.
J7,C9 W6, 11	L1 Q1, 2, 4, 5 R1-3, 4-10 15-18 U2-6, 9-11, 13, 18
A5	
C1-8, 8 J1-3	

C7 NOT ASSIGNED

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q1, 2, 4 Q5	1853-0450 1854-0810
U2, 9	1826-0471
U3	1826-0861
U4, 6, 11, 14, U5, 10	1820-1997 1820-1934
U13	1820-1199
U15	1820-1218
U18	1820-2024

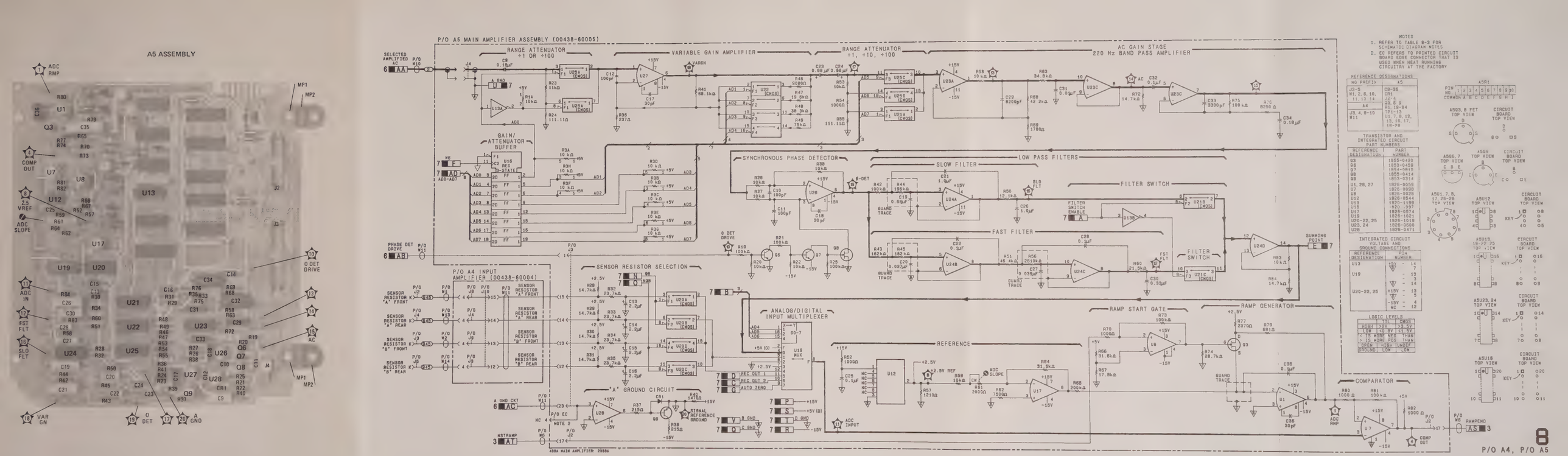
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATION	PIN NUMBER
U4, 6, 11, 14, 16	+15V - 20 -15V - 10
U13	+5V - 14 -5V - 7
U15	+5V - 16 -5V - 8

LOGIC LEVELS

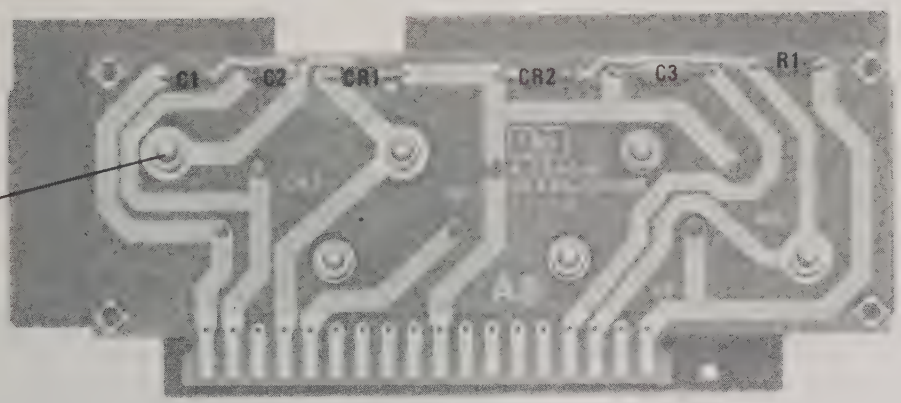
	TTL	CMOS
HIGH	+2V TO +5V	2.5V TO +5V
LOW	+0.5V TO +0.8V	+1.5V TO +1.5V
IS MORE NEG THAN		
IS MORE POS THAN		
OPEN	HIGH	UNDEF
GROUND	LOW	LOW

A5U2, 9 TOP VIEW
A5U3, 5, 7, 8, 10, 12 TOP VIEW
A5U4, 6, 11, 14, 16 TOP VIEW
A5U13 TOP VIEW
A5U15 TOP VIEW
A5R1
CIRCUIT BOARD TOP VIEW

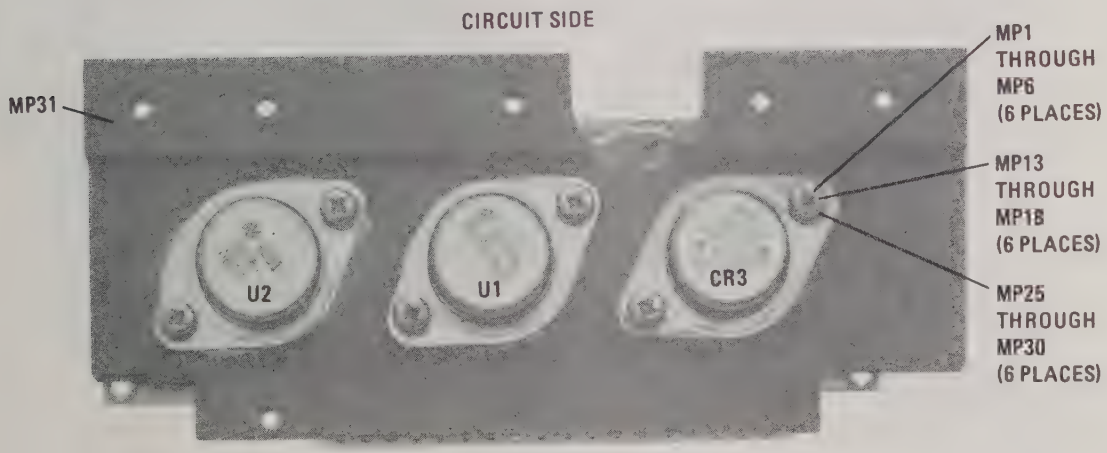

A5 ASSEMBLY
P/O A5 MAIN AMPLIFIER ASSEMBLY (00438-60005)
RANGE ATTENUATOR ÷1 OR ÷100
VARIABLE GAIN AMPLIFIER
RANGE ATTENUATOR ÷1, ÷10, ÷100
AC GAIN STAGE 220 Hz BAND PASS AMPLIFIER
GAIN/ ATTENUATOR BUFFER
SYNCHRONOUS PHASE DETECTOR
LOW PASS FILTERS
SLOW FILTER
FAST FILTER
FILTER SWITCH
SUMMING POINT
P/O A4 INPUT AMPLIFIER (00438-60004)
SENSOR RESISTOR SELECTION
ANALOG/DIGITAL INPUT MULTIPLEXER
'A' GROUND CIRCUIT
REFERENCE
RAMP START GATE
RAMP GENERATOR
COMPARATOR
NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES
2. EC REFERS TO PRINTED CIRCUIT BOARD EDGE CONNECTOR THAT IS USED WHEN HEAT RUNNING CIRCUITRY AT THE FACTORY
REFERENCE DESIGNATIONS
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS
LOGIC LEVELS
P/O A5 MAIN AMPLIFIER
P/O A4, P/O A5
8-61/8-62

A8 ASSEMBLY

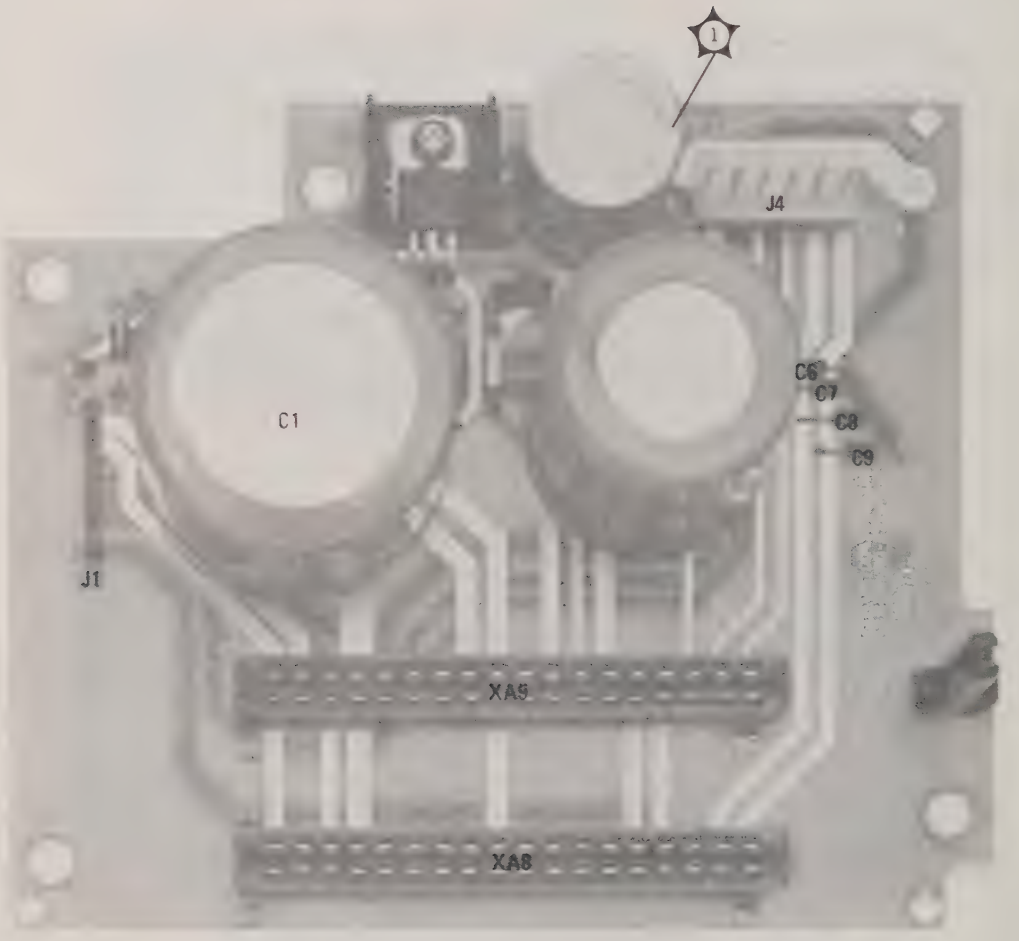
COMPONENT SIDE

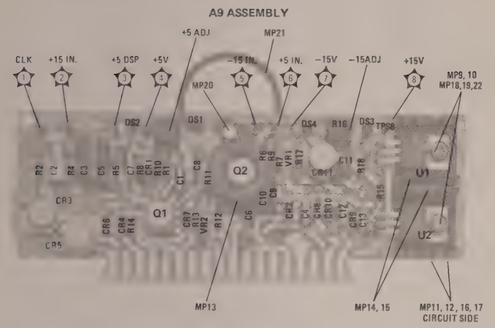


CIRCUIT SIDE



A10 ASSEMBLY





DANGER HAZARDOUS VOLTAGE

WARNING

MAINS VOLTAGE IS PRESENT AT THE LINE MODULE WHENEVER THE POWER CABLE IS CONNECTED. WHENEVER THE POWER CABLE IS CONNECTED BE EXTREMELY CAREFUL WHEN WORKING IM PROXIMITY TO THESE AREAS. THESE HAZARDOUS VOLTAGES COULD CAUSE SERIOUS PERSONAL INJURY IF CONTACTED.

P/O A10 POWER SUPPLY INTERCONNECT ASSEMBLY (00438-60006)

A8 RECTIFIER ASSEMBLY (00438-60008)

+5V BRIDGE

DISPLAY +5V REGULATOR

U1 LINE POWER ASSEMBLY (0960-0443)

P/O A9 REGULATOR ASSEMBLY (00438-60009)

DIGITAL +5V REGULATOR

CURRENT PROTECTION

+5V(DSP) INDICATOR

CROWBAR

LINE FILTER

LINE VOLTAGE 100, 120, 220 OR 240 VAC +5%, -10% 48-66 Hz AND 100, 120 VAC +5%, -10% 360-440 Hz

POWER CABLE

+5V DIGITAL GROUND

+5V DISPLAY GROUND

INPUT GROUND

438A POWER SUPPLY: 2333A

NOTES

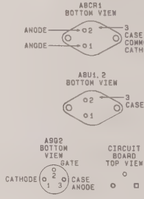
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES
2. VALUE OF F1 IS:
   1.0A 250V FOR A LINE VOLTAGE OF 100-120 VAC.
   500mA 250V FOR A LINE VOLTAGE OF 200-240 VAC.

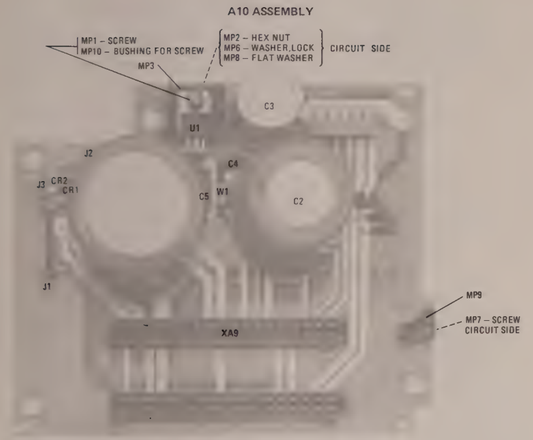
REFERENCE DESIGNATIONS

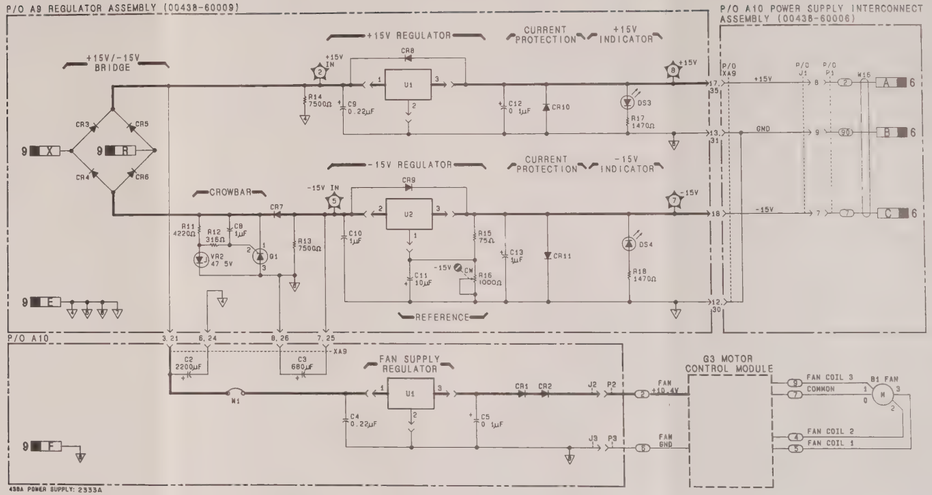
NO PREFIX	A9
C1 S1 T1 U1 W8,12	C5-7 CR1, 2 DS1, 2 Q2 R1-10 TP1, 3, 4, 7 VR1
A8	A10
C1-3 CR1-3 S1 U1, 2	C1, 6-9 J1, 4 TP1 XA8, XA9

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A8	
U1	1826-0433
U2	1826-0677
A9Q2	1884-0244





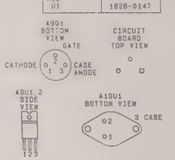


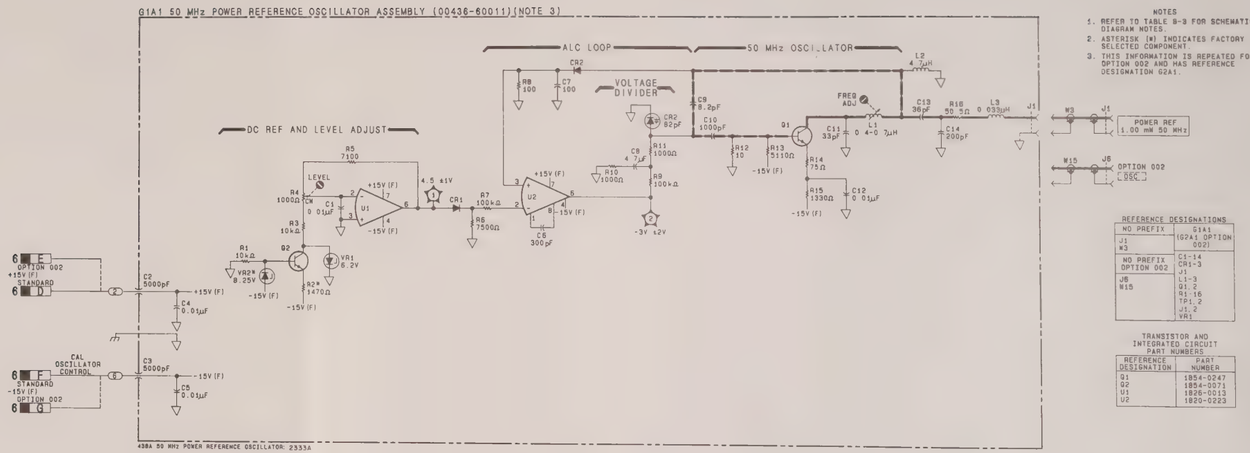
NOTES
1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.

REFERENCE DESIGNATIONS	
NO PREFIX	A10
B1 G3	C2-5 CR1, 2 J1-4 U1 W1, W16 XA9
A9	
C8-13 CR3-11 DS3, 4 G1 R15-18 TP2, 5, 6 J1, 2 VR2	

TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
A9	
G1	1884-0244
U1	1826-0807
U2	1826-0527
A10	
U1	1826-0147





NOTES

1. REFER TO TABLE 8-3 FOR SCHEMATIC DIAGRAM NOTES.
2. ASTERISK (*) INDICATES FACTORY SELECTED COMPONENT.
3. THIS INFORMATION IS REPEATED FOR OPTION 002 AND HAS REFERENCE DESIGNATION G2A1.

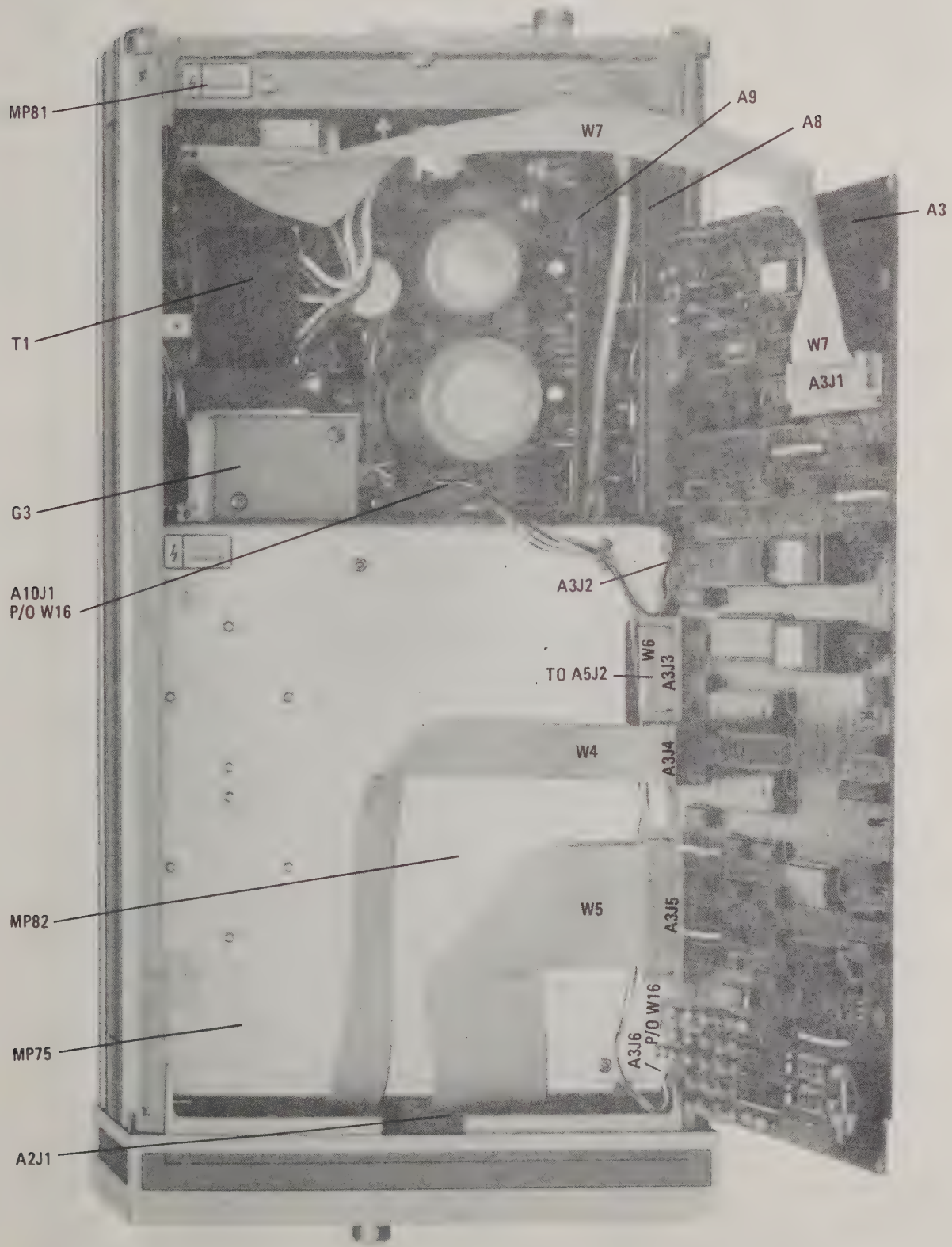
REFERENCE DESIGNATIONS

NO PREFIX	G1A1 (G2A1 OPTION 002)
J1 W3	
NO PREFIX OPTION 002	C1-14 CR1-3 L1 L1-3 Q1, 2 R1-16 TP1, 2 U1, 2 VR1
J6 W15	

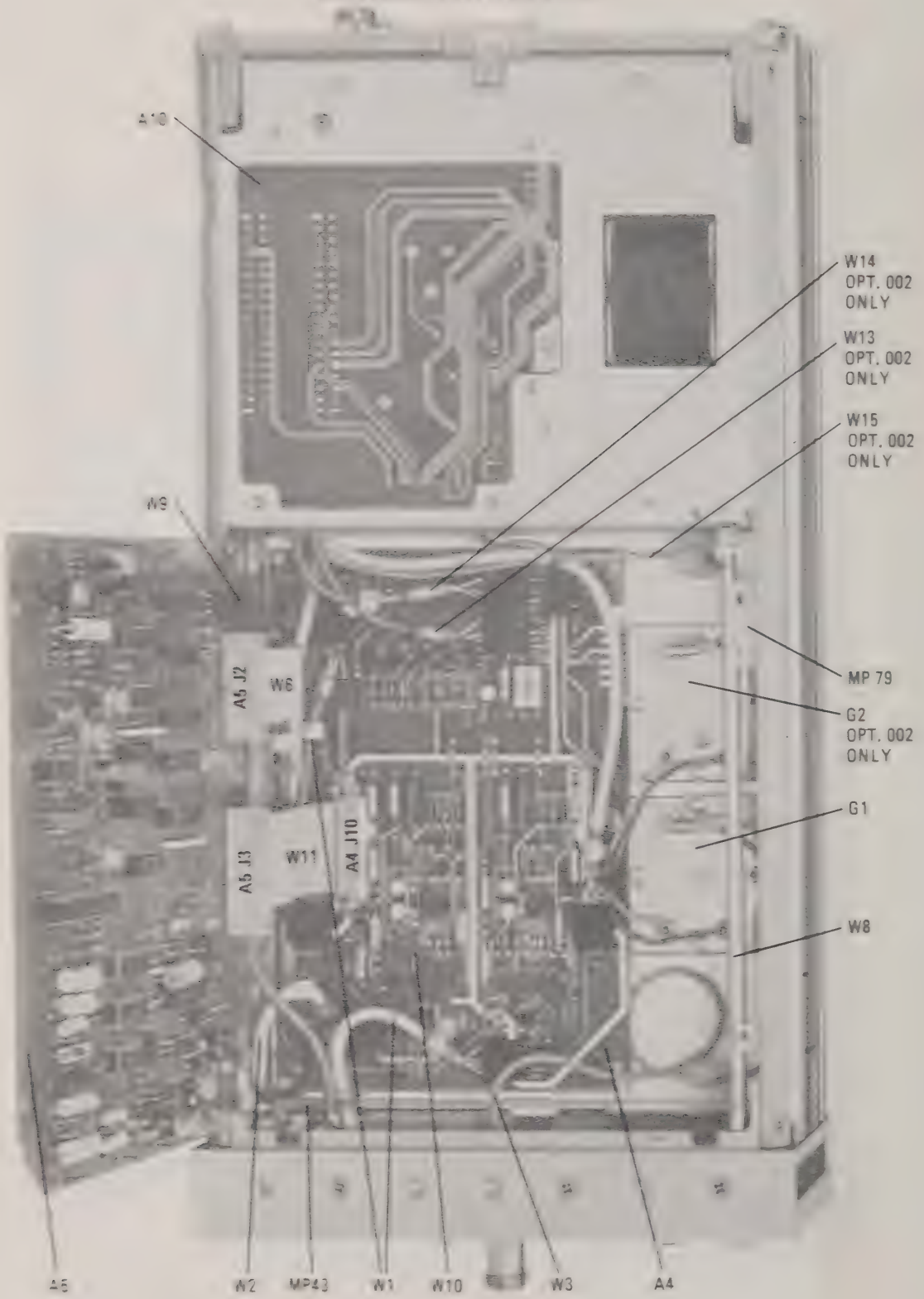
TRANSISTOR AND INTEGRATED CIRCUIT PART NUMBERS

REFERENCE DESIGNATION	PART NUMBER
Q1	1854-0247
Q2	1854-0071
U1	1826-0213
U2	1820-0223

INTERNAL TOP VIEW



INTERNAL BOTTOM VIEW



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COMPANY

ADDRESS

TECHNICAL CONTACT PERSON

PHONE NO. EXT.

MODEL NO. SERIAL NO.

MODEL NO. SERIAL NO.

P.O. NO. DATE

Accessories returned with unit

☐ NONE ☐ CABLE(S)

☐ POWER CABLE ☐ ADAPTER(S)

OTHER

over

HEWLETT PACKARD

Should one of your HP instruments need repair, the HP service organization is ready to serve you. However, you can help us serve you more effectively. When sending an instrument to HP for repair, please fill out this card and attach it to the product. Increased repair efficiency and reduced turn-around time should result.

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☐ POWER CABLE ☐ ADAPTER(S)

OTHER

over

5955-8108

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

5955-8108 Printed in U.S.A.

Service needed

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☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

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5955-8108 Printed in U.S.A.

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OTHER _____

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Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

_____

_____

_____

_____

_____

_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

9320-3896 Printed in U.S.A.

Service needed

☐ CALIBRATION ONLY

☐ REPAIR ☐ REPAIR & CAL

OTHER _____

_____

Observed symptoms/problems

FAILURE MODE IS:

☐ CONSTANT ☐ INTERMITTENT

SENSITIVE TO:

☐ COLD ☐ HEAT ☐ VIBRATION

FAILURE SYMPTOMS/SPECIAL CONTROL SETTINGS_____

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_____

If unit is part of system list model number(s) of other interconnected instruments. _____

_____

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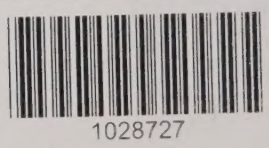

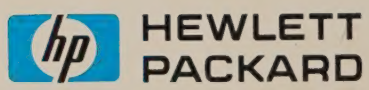

HP Part No. 00438-90003

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